FUNCTIONS OF A PLANNING DEPARTMENT.

Paper presented to the Institution, Luton, Bedford and District Section, by B. C. Jenkins, M.I.P.E., Section President.

IN preparing this paper for the consideration of our members, the author was faced with two difficulties. The first was that on a previous occasion he had given a paper which dealt very largely with the functions of a planning department ; the second difficulty was the utter impossibility of deciding what any given firm would lay down as *planning department* functions. In order to make the paper interesting to everyone, whether they had heard the previous paper or not, it was decided that the subject should be dealt with along more or less unorthodox lines but in a manner which should give ample scope for discussion. In consequence, the paper will not make reference to the various forms and paper work which must inevitably be part and parcel of the functions of any planning department in a large modern manufacturing organisation.

It is impossible to lay down arbitrary lines of demarcation between planning department activities and those of other interlocking departments. The larger and more comprehensive the manufacturing activities of any organisation become, the greater is the tendency towards segregation and specialisation of given activities, all of which may be termed planning functions. In the smaller manufacturing organisation, more activities of diverse but allied nature will, of necessity, be placed under the control of one departmental chief.

The author has taken part in many discussions on the subject of planning activities, and has heard many diverse expressions of opinion as to the necessity for and the wisdom of organised and centralised planning. It is generally agreed that planning activities are certainly as old as manufacturing history, and many competent engineers of the old school argue that the centralisation of such activities in one or more departments has not increased the over-all efficiency of the manufacturing plants, but has definitely taken away much of the interest from the industrial life of production personnel.

Let us now consider in the broad sense what we mean by planning

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activities and decide what is their relationship to the complete organisation. In thinking this problem over, I was struck by the similarity of a manufacturing organisation to the human body and its various parts and functions, and propose to use it as an analogy, so far as it suits, for the purpose of this paper. The higher managerial and directorial functions may be regarded as analogous to the brain of the human being, the planning department as the nervous system, and production management as the heart and arterial functions. I am aware that many amusing questions can arise if this analogy is carried too far and would state, in advance, that no attempt will be made to answer such questions.

Just as the brain, through the nervous system, directs and controls the actions of the body, so the higher management directs and controls every production activity through the planning department. Carrying the analogy still further, we find the nervous system has another and very important function to perform in its relation to the brain, that is, the transmission back to the brain of messages from every part of the body, however remote. Such messages are sent back for decision and direction, and the more serious the necessity for direction, the more insistent becomes the nervous system in getting such direction.

I am not sufficiently versed in anatomy to know whether I am correct in my statement when I say that, under certain conditions of urgency, the nervous system acts first and sends the message to the brain practically simultaneously. As an instance, one touches a piece of hot iron and muscular actions takes place before the brain realises fully what has occurred. In another case, one senses danger in a given situation and takes action to get out of danger practically automatically, leaving reasoning till later. The efficient planning department must act in the same manner, must transmit its messages to the management, and must be insistent, until appropriate action is taken. It must be prepared to take action in case of necessity before receiving definite instructions, and must get out of dangerous situations without delay.

The nervous system can also be regarded as watching over the general health of the body and, in many cases, is the only thing which informs the brain that all is not well with some part or function of the body. Outwardly, everything looks O.K., but by transmitting messages in the form of pain, the brain is informed that things are not all they seem to be. Just as the efficiency of the human body is dependent upon the healthy condition of all its members and parts, and the proper co-ordination of their actions, so is the industrial organisation.

The primary function of the planning department is to get and maintain that proper co-ordination, to see that it is maintained in a healthy condition, and to be insistent upon drawing attention to

those spots which are in an unhealthy condition. Obviously, like the nervous system, the planning department will not always get the condition rectified, but again, like the nervous system, it must be insistent upon the unsatisfactory condition wherever it may appear, until such time as corrective action be taken. These remarks may be taken as outlining the relationship of planning to other activities of the organisation in a general sense.

Getting down to detail functions and the point at which the planning department becomes physically operative, one starts at policy. Such a department cannot operate efficiently without knowledge of managerial and directorial policy, particularly what one may term long distance policy. Without such knowledge, it is impossible to determine with any degree of accuracy the type and layout of buildings required. It may be necessary in the early stages, for instance, to build and equip a factory for the complete fabrication of a given article, well knowing that at a later stage the volume of production will be greatly increased, thus necessitating new buildings and re-layout of plant and services. Buildings for the various phases of manufacture will require tremendous constructional differences, and if the plant is efficiently laid out, each stop will bear a locational relationship to every other. With proper knowledge of forward policy, it is possible to so lay out and construct the buildings in a manner which will dovetail into the major plan as it develops step by step. The same remark applies to the installation of services such as gas, water, electricity, and sanitation. The positional relationship of generating stations, converter houses, heat generating plant, air compressors, and many other service items, if determined in the original instance in relation to a major plan which is to come in at a later stage, can be the means of saving much needless expenditure on reorganisation, to say nothing of valuable time.

Buildings.

Buildings in themselves may not be considered as coming within the scope of planning department activities, but it will be agreed that, whilst the actual buildings both as regards type, materials, and construction are a job for the specialist, they become, in effect, one of the major tools with which the planning department has to work. If the buildings are to be suitable both as regards type, size, shape, floor loading capacity, and a thousand and one other things, then the planning department must, of necessity, be prepared to take an intelligent interest in such matters. I do not intend to go into this phase of planning activity to any great extent, but would impress upon all planning engineers the importance of studying this side of the business, as the old method of housing productive activities in whatever buildings may be available cannot be allowed

to continue, if this country is to hold its place in world industry.

Buildings and plant layout should be as close to the ideal as it is possible to get, remembering all the time that the one objective is flow of material and flow of production, and that goes, whether the plant be large or small, and whether the type of manufacture be of standardised nature or constantly variable. If one would only take the trouble to follow, say, half a dozen pieces in their passage from material receiving stores through their manufacturing processes until they reach the point of despatch as finished assembled articles ready for sale, the importance of this aspect of flow would be fully realised. We all spend time and money to knock off seconds in machining and assembly operations, ingenious and costly tools being made to bring such reductions into effect. We then calmly proceed to spend hours in carrying the same materials back and forth owing to faulty plant layout or unsuitably related buildings.

Raw Materials.

For the purpose of this paper, material as supplied to the plant can be regarded as raw material, although it may be partly manufactured, such as castings, stampings, bar material, etc. Generally speaking, such materials will be specified by the engineering department in consultation and agreement with the metallurgist and will be bought by the purchasing department to the specification laid down. The interest of the planning department in such materials would appear to commence when the material arrives in the factory. In actual practice, it must commence before ordering.

The engineering department is primarily concerned in getting materials of correct shape and strength to carry out the functions for which they are designed, in some cases weight being a material factor. The metallurgist is interested in seeing that materials are of adequate strength and of suitable quality for the stresses to which they are to be subjected. He also is interested in seeing that the materials are supplied in such condition that proper manufacturing operations can be carried out; but always remember, his main interest is quality, and rightly so. The purchasing department must of necessity be governed by the requirements of the engineer and the metallurgist, and their one aim in life is to get such requirements at the most competitive price.

Most of us have suffered from castings which were apparently made from glass bottles, stampings which run as true as a dog's hind leg, with $^1/_{32}$ in. machining allowance on one face and $\frac{1}{2}$ in. on another, also having badly chilled spots just to help things along. Also with bar material which was badly bent, variable in size from bar to bar, which was either too woolly to get a finish or too hard to turn, or which was unsuitable for threading.

We have all heard the plaintive wail of the inspection department, that the stampings were of the right brinell and that the castings were as good as we could expect, seeing how difficult a foundry job it was and that the poor foundry man had to work in sand, and in the finish we have all ended up by blaming the purchase wallah for buying cheap muck. The planning department must play its part if such difficulties are to be overcome. Design must be checked, not only from a machining standpoint, but from the point of view of the manufacture of castings or stampings to see if modifications cannot be made to ease manufacturing difficulties, and machining allowances must be specified.

Material specifications must be checked to see that materials are supplied in a proper and machinable condition. Above all, the purchasing department must be given every assistance possible in getting the *right* materials at the most competitive price. No purchasing department will knowingly cause production to spend an extra penny on fabrication to save a halfpenny on material, and it is the duty of the planning department to see that the purchasing personnel have all the facts placed before them, to enable them to purchase materials at the lowest over-all economic price.

Design of Product.

The question as to whether the planning department or any production department should be allowed to enter into questions of product design is one which has led to heated arguments on many occasions. It is argued that the requirements of production and production planning tend to limit engineering development, to the detriment of the final product.

Proper co-operation between planning and engineering staffs should not only be allowed but should be regarded as essential to efficient and economic production. Such co-operation, carried out in a spirit of mutual helpfulness, cannot be detrimental to the interests of the firm, the engineer, or the product. Both departments have a common interest, which is, to supply the best possible article to the particular market in which their product is sold, at a price lower than that of competitive lines. This aim can only be achieved when both sides fully appreciate the requirements and difficulties of each other. The planning engineer must check all engineering designs with a view to possible modifications which will lower material or production costs, but such modifications must not be allowed to basically alter the requirements of the engineer, to the detriment of the finished product. One generally finds that most of the suggested modifications are of comparatively simple nature, which in no way materially affect design, but which either allow existing tools or equipment to be used or, alternatively, lower the cost of new equipment required..

Slight alterations in dimensions will often allow of standard tools being used instead of specials or will bring the manufacture of the part within the scope of standard machinery. Alterations in contour will often enable a standard chuck to be used instead of first operation jigs being required. The addition of locating spots of machining lugs or bosses, will often simplify enormously the design of first operation jigs, and when used in connection with pre-viewing fixture, will often prevent scrap castings or stampings reaching the machines.

The close study of bar parts such as pins, bolts, and other articles of similar nature will reveal the possibility of reducing the number of variants to a degree which will enable much saving in set-up time and duplication of tools and gauges. The number of collets and pusher tubes for automatics and capstans can be reduced and longer runs made with comparatively little change in set-up.

Analysis of sheet metal parts will often lead to modifications which can save hundreds of pounds in tool costs, or by eliminating a design which would be a troublesome production job, can lower production costs. Alternatively, alteration may enable a smaller sheet size to be used or a standard sheet instead of a special, again lowering material costs. Such modifications can often be made without the slightest detriment to the product from an engineering standpoint.

These remarks should not be taken as criticism of the engineering draughtsmen, as many of the suggested alterations are the result of local production conditions within the plant or the existence of equipment or plant of which the draughtsman has no knowledge.

As I stated in my opening remarks, I do not intend to go into detail planning and make reference to the various forms used, as this was fully covered in my earlier paper "The Organisation of Production Engineering" but propose to keep to a more or less general discussion of planning department functions touching upon certain aspects which may not receive the attention they deserve in the conventional write-up.

Operation Sequence.

It must be realised that the compilation of the operation sequence is one of the most important functions of planning, and a fit field for the best brains of the organisation, involving a deep knowledge of every phase of productive activity. The first class planning engineer must have a complete knowledge of the various classes of machinery and equipment available within the plant or purchasable in the market. He must be capable of understanding the economics of manufacturing as applied to his particular problem and produce, if he is to compile operation sequences efficiently.

The determination of primary locating points and master loca-

tions from which to machine castings and stampings can be regarded as the foundation upon which all jig and tool design must be built. However good the jig and tool design may be, if the foundation upon which they are built is bad, the result will be, to say the least, indifferent. All operations should be carried out from the basis of the master locations except those operations which call for local accuracy to some other particular dimension only.

When deciding the type of machine to be used in the manufacture of a given component, it is easy to make mistakes in an endeavour to produce, in what seems to be the most efficient manner. The easiest job to plan is one which justifies the use of high grade special purpose machinery and equipment, but such jobs are few and far between in the average British factory. The worst job to plan is the small volume one, where a high degree of accuracy is required.

Heavy expenditure on machinery, jigs, and tools for large volume production should still result in a low tool cost per piece, if it is to be justifiable. On the contrary, very moderate expenditure on low volume production often shows what may appear to be comparatively heavy tool cost per piece. Decisions can only be made after a close study of the economic aspects of each method of production. The general trend will be found to be, that over-lavish expenditure takes place on the larger volume jobs, whilst insufficient money is usually spent on the small volume jobs. It is only by a very close study of both the tangible and measurable costs and those intangible items which are so difficult to measure, that one can decide the most economic method of production.

It should be remembered that complexity in itself is of no value and that the simpler and more flexible the machine, equipment, and method can be kept, the better. Obviously, such a statement requires qualification and this is where the study of economic factors comes in. It would be absurd to suggest, for instance, that a bar part which is consumed in reasonable quantities, should be produced on a centre lathe. On the other hand, no one would be prepared to set up a six-spindle bar automatic for a dozen parts.

The centre lathe, the bar lathe, and the automatic all have their particular spheres of usefulness and justification, and it is comparatively easy to determine which is the most economic to use, but when one comes to the decision as to how much shall be spent on tooling the six-spindle automatic, one begins to get into a little deeper water. A well-planned, well tooled, bar job on a multi-spindle automatic is one in which the life between grinds of all tools in use is reasonably consistent. Have a good look at some of the stunt jobs which are frequently used to demonstrate the efficiency of a bar automatic ; at a casual glance it seems a wonderful achievement to tool a machine to produce in the demonstrated time a complicated article. Check the same job being produced under production

conditions at a later stage, and it will frequently be found that half the tools have been thrown out and others replaced by simpler and more easily replaced tools. It is not the time to produce the single piece which counts, but the setting costs, machine costs, and other burden costs, plus production labour time to produce the day's run, which determines the real efficiency.

Let us examine the question of drilling a cylinder block for a car which is selling at the rate of 100 a day. One immediately visualises a battery of complicated multi-spindle drilling machines as being the correct method of carrying out the operation. A little deeper consideration of the possibility of engineering changes, re-design, etc., and one becomes a little more cautious, and the answer finally becomes one of a combination of multi-spindle and single-spindle machines. The multi-spindle machines being of unit type construction enable much of the machine to be used even after a drastic re-design. One could carry on indefinitely giving instances which constantly arise in the daily life of the planning engineer which demand the faculty of analysis to a high degree.

Design of Tools and Equipment.

The general lines of design of tools and equipment should be laid down by the planning engineer using the same groundwork and method of analysis as when choosing machinery and laying down the sequence of operations. The type of jig or tool required for any particular operation is, in effect, another step in the same general plan which determined the machine and operation sequence, and unless proper and adequate direction be given to the drawing office, the draughtsman would need to be a thought reader to carry out the wishes of the planning engineer. It may be argued that such a method takes the initiative from the draughtsman, but this is far from being true, for in no case should the instruction be so rigid that the draughtsman is precluded from improving upon the method of construction, design, and manufacture of any given piece of equipment. Generally speaking, one can say that, although the system of instruction sheets be strictly adhered to, the resulting designs are 100% the product of the brains and skill of the tool designer.

Suggestions from the draughting staff often result in a replanning of a particular part, as the competent jig and tool designer is, and is expected to be, a keen critic of the instructions given on the sheet. In fact, one may term the designing staff as the first line of protection from error on the part of the planning engineer. The same economic law operates in determining the design of jigs and tools as for machinery, a comprehensive layout being justified on volume jobs while grading down is necessary on the small volume job.

One could write a complete paper on the subject of jig and tool

design and still only touch the fringe of the subject, and even then the paper would be of doubtful value. Product and production conditions, variation in volume requirements, and many other things, have a major effect on jig and tool design in the detail sense. On the other hand, certain broad principles can be said to apply whatever the product or the volume may be and failure to observe such principles usually ends up in the production of indifferent equipment. Earlier in this paper, in discussing the layout of operation sequences, the need for master locating points was stressed. Jig designers should remember that, in manufacturing jigs, the tool room and the tool inspection department can be helped considerably if the same point is considered. Datum faces can save considerable set-up time, both in manufacture and checking. It is often an easy matter to arrange for locating bosses on complicated castings, which will save many hours work in tool room or die shop and at the same time ensuring that the jig or tool casting is machined in such manner that the clearances in the non-machined portions of the casting are evenly spread as the draughtsman intended. As a matter of interest, look over a few jigs and fixtures, and see how many you can find where the component has ample clearance at one point and practically fouls at another. In other cases, the evidence is there of the jig having to be cleared away because the casting has fouled at one or more points.

This matter of clearance in jigs is another principle which rarely gets the attention it deserves, in fact some designers seem to take careful pains to fit the jig to the component as tight as a glove. Remember, clearance costs nothing except perhaps a little more cast iron in the jig, but the absence of adequate clearance can produce scrap work if fouling occurs. Worse still, unless the jig is designed in such manner that the operator can load and unload the parts with ease, the firm pays a premium on every piece produced, without any one being one cent better off. The operator suffers from abrasions, his temper gets frayed, the quality of his work drops, and his opinion of the jig designer is unprintable.

Chip clearance and the supply of cutting compound to the tools is another one of those irritating little defects which constantly arise; little, in the sense that a few minutes forethought would have corrected matters, but costly in the matter of tools burned up owing to lack of coolant, or the time taken to remove adequately chips from the jig.

In other cases where adequate provision has been made for coolant supply to the tools, the angle of the operator has been neglected, and if he uses a full flood he gets half drowned or, alternatively, half the coolant finds its way to the shop floor. Every effort should be made to give an adequate supply of coolant with protection for the oper-

ator and return channel, which will ensure coolant draining within the area of the machine table.

In the matter of chip clearance, the raising of the locating faces with tapered effect on the sides will often enable chip to tend to run clear and will always enable locating faces to be cleaned more rapidly. Naturally, no fixed rule can be applied to all jigs. Each is a law unto itself, but careful consideration of this aspect will always pay dividends, even if the jig costs a few shillings more.

Clamping arrangements are another source of irritation more often than not. Just watch the operator pick up that ½ in. spanner only to find that the head of the set-screw is $^7/_{16}$ in. or some bastard size. He puts it down, finds another after five minutes search, uses it, picks up the ½ in. spanner to lock some other nut or set-screw, and after using half a dozen different size spanners he has finally loaded the jig. The variations in spanner sizes should be kept to a minimum, and should always be of standard size. Obviously, where quick clamping actions are justifiable, they should be used. We in this country have so far been slow to adapt ourselves to the air and hydraulic methods of clamping, owing to the question of cost, but I am of opinion that in the volume production plants we should find it economically practical to adopt them in many instances.

Standardisation of detail parts can save a mint of time and money, and are just as essential as standards in any other engineering field, but care must be used in laying out such standards.

Let us take, for instance, jig bushings. At first sight, it would seem to be commonsense to take a range of drill bushes, say ¼ in., $^5/_{16}$ in., and ⅜ in. diameter, and make the outside diameter of one standard size—from a bush production point of view entirely satisfactory, but the number of jobs which would receive the wrong size drill or reamer when using slip bushes would very soon show a loss. Slip bushes for ¼ in. drill or reamer should be of one standard outside diameter., $^5/_{16}$ in. bushes of another and larger diameter, and so on up the scale, but in many shops one can pick up drill and reamer bushes of the same internal diameter but of widely varying outside diameter just for lack of standardisation.

When designing jigs and fixtures of the indexing or turn over types, or which require to be frequently moved along the machine table, care should be taken to make every such indexing or moving as easy and frictionless as possible. In the case of heavy jigs, personal injury may result from neglect of this factor, and in all cases loss of time occurs.

I am aware that my remarks on jig design have touched principally on what one might term detail points, but if designers will get into the habit of studying such details I have no fear as to what will happen to the major points, and they will receive all the atten-

tion necessary. Details seem to be nobody's baby, but everyone is careful and interested in the major points of design, whether it be jigs, tools, or any other engineering product. Speaking generally, it is the little things in life which make the difference between success and disaster.

I do not propose to enter into discussion about recording systems, tool manufacture, and inspection, as these were dealt with in detail in my previous paper.

Shop Layout.

The same question of managerial and directorial policy enters into the question of shop layout as when dealing with buildings. Product flow is the keynote and the shop layout must be based on obtaining the best possible flow under all circumstances.

If one has knowledge as to future expansion possibilities and the probable site of future building activities, the layout can be so arranged that expansion can take place with a minimum disturbance of existing activities. Failing such knowledge, one usually finds that every machine, conveyor, stove, and the thousand and one items which go to make up the organisation have somehow got into precisely the opposite place to that required when expansion takes place.

The planning engineer cannot easily disclaim responsibility. Even under such conditions, he must always visualise the possibility of expansion and study the probable direction in which it is likely to take place and lay his plans accordingly. Even if he does that, I can promise he will still get all the trouble he wants and quite a little to spare. As a matter of fact, if a live planning engineer cannot see possibilities of expansion, he should be looking for another berth, because he won't be wanted for so very long, anyhow. This matter of layout is so vital that I venture to repeat certain matters which appeared in my previous paper.

Accurate scale plans of each shop should be made and blue prints taken off. These, read in conjunction with the master factory plan to enable positional relationship of the various shops to be determined, will then enable one to decide the type of activity and direction of flow desirable for the production required. Obstructions such as supporting pillars and any projections must be clearly marked and dimensioned to scale, positions of doors and service mains should be shown and any other similar items which must be avoided or which are likely to impede flow.

Scale dummies of each machine and piece of equipment which is to be positioned on the floor must be prepared, care being taken to see that allowance has been made for maximum interference points on all machines. It's just too bad to find that when using the maximum stroke on the planing machine it goes through the

wall on one stroke and knocks a man over who is walking down the aisle on its return stroke. I think that clearly illustrates what can happen if sufficient care is not exercised. These accurate dummy machines can be moved about like the men on a chess board, a very apt analogy as it happens, for one gets checkmated very frequently when playing this game of shop layout, and the best laid scheme can be brought to nought by some little unforeseen snag.

The technique of using dummies to determine layout is not so easy as it seems at first sight, and certain preliminary steps can save time and temper.

Let us take a shop of known shape and size, which has been accurately drawn to scale, with all interference points shown. We know exactly what functions we want to perform in the shop, have decided out lines of flow throughout the shop, the points at which raw material will enter and the finished material will leave, and are satisfied that we have accurate dummies to use in layout. The logical thing to do seems to be to immediately commence to pin our dummies out, according to our pre-determined lines of flow, section by section, until the job is completed. It is quite possible that if you have adequate space to deal with, an ideal shop to lay out, projection and interference points happen to be kind to you, and you have all the luck in the world, you may be successful at the first attempt. Personally, I have never yet had the luck to find all those conditions fulfilled, and I think the experience of most planning engineers is similar.

The best method of procedure in my own personal experience (please note I make no claims to be an expert at this layout game although I might have been silly enough to make such claims until I was taught through bitter experience how little I really knew of the game) is to take the dummies and pin them out on mill-board strip of measured length, equivalent to the length of the shop if the lines of flow are to be in that direction. Alternatively if the flow lines are across the shop, use a measured length equivalent to the width. Space the dummies the correct distance apart, as you would in the layout ; each strip should contain only those dummies which go to make up a given machine or assembly line, or a section of co-related activity.

In some cases it will be found that one strip of correct length will not take the desired, and complete, machine or assembly line ; use a second strip in such cases still keeping strip to correct length. In other cases it will be found that strip is only partially filled but strip should not be cut down at this stage. It will now be seen that whole sections can be moved about in relation to one another ; measurement of the vacant section on one strip may show that the machines laid out on another can be brought into that line with a minimum of waste space. Two lines, each of which take up more

than one strip, may be found to so marry up that the two activities can be got into three complete machine lines. Various moves and countermoves to get relative positions and lines of flow as near the ideal as possible can be made at this stage.

Having arrived at a point at which the number and relative position of the various lines is a known factor, the strips can now be cut down and the occupied sections pinned to layout print, which should be firmly fixed to a flat softwood board. As each line is pinned on the layout, walking and trucking gangways should be indicated. This can best be done by the insertion of pins at either end of the layout between which cotton or thread lines can be drawn taut. This procedure can be carried out until the whole of the lines have been pinned out on the shop layout print.

Care should be taken to lay in the sections and lines without waste of space, even though it becomes evident that ample space is available and to spare. Re-allocation can be made finally, leaving vacant space for extension of activities. Flow lines for each section or line of activity can be indicated by using different coloured cottons stretched upon pins indicating flow of raw material through machining sub-assembly to final assembly or, at least, the final condition in which it leaves the shop which is being laid out.

At this stage one has reached a point when the general scheme can be checked by all interested parties, criticised from every angle of relative position and flow. Service departments should check provision made in the layout for their particular activities. After agreement has been reached, which will usually be after long and varied arguments and many changes and alterations have been tried out, and either accepted or turned down, one can proceed to draw up the final layout in detail. These remarks are not intended to cover the whole field of shop layout but are merely indicative of a system of using dummies which will give good results without too great a waste of time in pinning in every item of equipment and laboriously moving them about as separate items.

Shop layout is a field of activity which requires much specialised knowledge of widely divergent character and a good general knowledge of all manufacturing processes. It is not a job for the office boy or the odd job man, neither is it a spare time occupation, but a highly skilled job of work for which any ambitious youngster would be well advised to train ; but he must be prepared for many trials and tribulations, for no matter how good he may think the layout, he will be lucky if he half satisfies the various interested parties. But that must be taken as part of a game which can be of absorbing interest.

Purchase and Maintenance of Machinery.

Earlier in the paper the selection of types of machinery was touched upon, but one of the most important phases of planning

activity is the selection and purchase of new machinery. British industry cannot, in the general sense, adopt and use much of the specialised machinery used in large volume production, but it can and must use the same principles modified to suit particular conditions of industrial activity. Modification of a specialised type of machine may often result in a machine with sufficient flexibility to cover quite a wide range of product of like nature. Viewed from this angle it is often possible to justify the purchase of such a machine by the combined volume of a range of jobs of like nature.

Obviously, in the majority of British engineering shops, the plant must be of more or less standard types of machine tooled up to the best advantage. The difficulty of selection becomes apparent when one comes to consider the standard centre lathe. Half a dozen manufacturers may offer a lathe of similar size and pattern which, to the untrained, appear to be almost twin brothers, except for finish, but the price may range between £150 and £1,000. Each of these machines has its own particular field of usefulness, and its purchase can be justified under given conditions. No one would purchase, say, a Pratt & Whitney or Lang tool room lathe for low grade work with wide tolerances, neither would they use such a machine for roughing work, nor would they expect to get high grade tool work to fine tolerances from the £150 machine.

The first line of reasoning must be that one never gets more than one pays for, particularly in the machine tool industry. Low priced, low grade machinery, like a cheap pair of boots, cannot be expected to stand heavy wear and tear. Machinery should be selected on the basis of its fitness for the duty it has to perform and its capacity to stand up to such duty for an extended period without serious breakdown and repair. The reputation for quick and efficient service on the part of the supplier and the rapidity or otherwise with which spare parts can be obtained must be taken into serious consideration.

Remember when you purchase machine tools one of the items you pay for is service. That does not signify that the supplier should be regarded as a wet nurse, but most reputable firms are prepared to give reasonably adequate service on demand. Naturally, a machine purchased without after service can be sold more cheaply, or shall we say at a lower price—not exactly the same thing. It is totally unsound to sacrifice efficiency to save money on the initial price of the machine, for maintenance and breakdown costs will soon absorb any such saving, and you will still be left with a poor machine.

Having decided the best type of machine for the particular class of work to be produced upon it, the machine should be checked to see that no unnecessary fittings are being purchased. A screw cutting lathe fitted with taper turning attachment, relieving attach-

ment, etc., can of course be used for plain turning, but if there is ample load for a simple rugged plain turning machine let the machine tool supplier keep the decorations—they will be more useful to him, and you will save the firm quite a useful sum of money. Naturally, there must be exceptions to this rule, and in certain instances one is amply justified in purchasing machines of a much more comprehensive nature than may be required for the particular work in hand.

The degree of flexibility of the plant is greatly increased if a leavening of more or less universal machines be injected into the general scheme of things, but such purchases should be closely watched and controlled. One tendency, which I have noticed from time to time, is that of purchasing a machine tool of given rated capacity, say a $1\frac{3}{4}$ in. bar automatic, for use on work which places the maximum load and stress on the machine, day after day and week after week. It does require courage to buy a larger machine, of higher rated capacity, which naturally costs more, when on paper the smaller and cheaper machine will handle the work. In the long run it will be found much more economical to purchase a machine with a reasonable degree of suplus capacity ; better work, lower tool costs, and much lower maintenance cost will be the result. Over stressing of the working members of the machine, besides producing poor work dimensionally, has an amazing effect on tool breakdown and consequently on life between regrinding. In a comparatively short time the machine is only fit for the scrap heap.

It is possible that when machine tool manufacturers get a little more interested in standardisation they will not only rate their machines in sizes but will also give us particulars of the maximum power input which the machine can safely absorb together with a suggested maximum input for general use.

The mention of standardisation brings me to an interesting point which arises when purchasing what may be termed duplicate machines of standard type. Let us assume we have in commission 20 capstan lathes of one capacity and type, all purchased from one manufacturer, giving every satisfaction both from a production and maintenance standpoint. We are now faced with the necessity to buy additional machines, either because of increased volume of the present product, or alternatively, to handle a new line of product of similar type. We have choice of buying, say, six competitive makes, all of excellent reputation and roughly in the same price class. The question is, shall we buy duplicates of the machines already in use, or buy from another supplier the new machines required or, alternatively, shall we split the order between the six sources of supply.

If we buy exact duplicates of the machines already in use we have the big advantage of 100% flexibility, all our tooling is inter-

changeable, and the volume of spare parts carried for service can be kept to a minimum. Operators retain their familiarity value and machine maintenance men also have only the same old problems, to which they have most of the answers.

My own reasoning is that we should standardise on the one source of supply until some other manufacturer can offer us machines either of higher quality or of more advanced design, or who can offer us machines of equivalent quality with a reasonable price advantage. Even then, in a shop on volume production, such a change should not be made until exhaustive tests have been carried out proving that the advantages gained will more than offset the disadvantages of lack of flexibility. When such change is decided upon the whole battery should be purchased from the one manufacturer so that the flexibility shall be regained so far as possible.

Frank interchange of views as to the virtues and failings of machines and equipment, should be fostered between production engineers; such views must be honest and fair. Personal bias toward one make and against another must not be taken into consideration and one must be prepared to back one's opinion by facts when criticising a given make of machine.

It is not possible, within the scope of this paper, to enter into detailed discussions on the various constructional features which must be studied before deciding on the purchase of machine tools. Bed and Column construction, type of strengthening ribbing, spindle dimensions, spindle mountings, gearing and shafts, clutches, speed changes, feed changes, tool supporting media and a hundred and one other things of major importance together with a host of smaller but no less important details must be taken into consideration and must of course to related to the type of work to be produced on a given machine.

One of the most important functions in any productive organisation, large or small, is machine maintenance. This function if carried out in a proper manner does far more than keep the machines turning round in a reasonably efficient manner. The old saying "A stitch in time saves nine," applies with particular emphasis to machine tools the only difference being that it is not so easy to apply the patch, which is the usual accompaniment of the nine stitches, to machine tools. The idea that the machine maintenance squad should be stuck in some hidden little corner of the shop, badly housed, badly lighted and equipped with a few machine tools which are the throwouts from production should be exploded at the earliest opportunity.

A cheese paring policy, in relation to machine maintenance, is one of the worst mistakes any management can make and unfortunately much of the loss caused by such a policy is not easy to prove. Inferior work, slower operation and lower production, a

greater dependence upon the human element, with consequently greater strain upon both operators and production personnel, is only a small part of the cost.

Nothing is more painful and disheartening to a skilled engineer, interested in his job, than neglect of machine tools. On the other hand some of the people who imagine that the machine operator of to-day has a most uninteresting task, should spend a few hours in a well maintained machine shop. The smooth, efficient way in which machines of to-day perform the most complex tasks, the poetry of closely co-ordinated motion, the precise and orderly manner in which cutting tolls move up to and away from the work, accurately producing a given piece, is really of absorbing interest to many men.

Machine maintenance is very similar to a doctor's job. Just as a broken bone or severe wound is obvious to the doctor, so the broken part or the badly scored spindle or bearing is to the maintenance man. Again, like the doctor, the maintenance man is often called in too late ; the harm is done and a complete lay up is necessary ; sometimes the cause of the trouble is obvious, at other times obscure.

The patient can help the doctor by describing his symptoms and so help to diagnose the trouble ; the machine is inarticulate and is dependent upon the care and attention of production personnel. Often a machine continues to be used long after it should be in the hands of the doctor ; the simple ailment—possibly need for adjustment—becomes really serious owing to neglect and the time and cost of repair greatly increased. If production operators and foremen watch for and report the little ailments as soon as they occur many major repairs will be avoided.

Regular periodic examination of all machines should be made by the maintenance staff and it is advisable that where batteries of machines of one type are in use a spare machine should be available, so that machines can be taken out of production for adjustment and overhaul. A comprehensive system of records of all repairs carried out should be kept, and from this record one can build up lists of those parts which require constant replacement and repair. Analysis of the results will enable suggestions to be offered as to re-design or strengthening of such parts, and this analysis can form the most valuable contribution the user can offer to the machine tool manufacturer. Modifications and alterations carried out to improve the efficiency of machines should always be passed to the manufacturer so that they can be embodied in the standard machine as supplied. If one fails to pass on such information it is no use expecting the manufacturer to improve his product to the satisfaction and benefit of his customer. In no branch of industry is co-operation between

manufacturer and user more necessary than in the machine tool field.

One must realise that whereas most things of a mechanical nature are designed for a given specific load, the general conditions of operation being known, in the machine tool field a thousand and one variables can come into operation which can materially affect the efficiency of the tool. When one examines the conditions of operation under which machine tools are expected to give satisfaction the difficulties of the machine tool designer can be appreciated. We take a casting or stamping, take heavy roughing cuts, removing the maximum amount of stock, in the shortest time and still expect the machine to finish work consistently to a thousandth part of an inch. We expect the same machine to operate, with some degree of efficiency, at 50 revs. per minute and 750 revs. per minute. In other cases one finds high-speed steel, Stellite and the carbide alloys, being used on the same machine. The designer is not born who can produce a machine which will consistently give a good result with such variables.

Take your troubles to the manufacturer, work with him in finding the solution, don't expect him to perform miracles and, above all, don't be too big to take advice. The manufacturer needs your help to find out what is happening under given conditions of application and you want his help to determine whether the particular application is fair or even feasible from the design side.

The machine maintenance man is the connecting link between planning, production, and machine tool manufacturer; he can probably help each one if he is given the opportunity and encouragement to do so. It you regard and treat him as a machine butcher, pulling machines to bits and sticking them together with bits of wire to keep them turning round, don't be surprised if he turns out that way. A good machine maintenance man is a craftsman in the highest sense of the word who, at the best, has to work under conditions which are by no means pleasant.

The machine maintenance department should have a well arranged store for spare parts with a properly laid out record system. Provision should be made for dismantling machines, with proper lifting tackle and transport facilities. Equipment for thoroughly cleaning all parts should be installed, a bucket of paraffin and some more or less clean rag is not sufficient. Machine tool equipment should be of ample capacity and of a thoroughly universal type, as the work the department is called upon to handle will require the greatest ingenuity, however well equipped the shop may be. It may be annoying to find valuable plant standing idle, waiting for a job, but it is far more annoying and costly to have production machinery standing idle waiting for parts to be made owing to the lack of such machinery.

Ideals and Aims of Industrial Planning

The title of this paper, "Function of a Planning Department," embraces so wide a field of activity that this paper, even when read in conjunction with my previous paper, can only be said to scratch the surface of the field, but as I have been asked to make some specific reference to planning as applied to small shops, I propose at this stage to make short reference to the ideals and aims of a modern planning department before dealing with that angle.

Much has been said, much has been written, about modern industrial methods. We are told from time to time that out methods are causing over production : That our system of organised planned activity is producing hordes of wage slaves performing their various tasks in a mechanical manner : That we have removed the interest and applied skill from the daily task and given nothing in return.

Let us examine these statements. Can it be said that we are over producing when many of the peoples of the world are still crying out for their requirements to be fulf lled ? If the system of distribution were as highly organised and planned as the productive side of industry the falsity of this argument would soon be proven. Can any thinking person argue that any system of production, in whatever age, did not involve a high percentage of hard manual work of a routine nature which called for only a modicum of skilled application ? Our present methods of production call for a much higher proportion of skilled labour and a much lower proportion of hard manual work than at any other period known to mankind.

Many of the so-called semi-skilled jobs call for quite as much skill spread over the working day as 75% of the jobs did in days when industry was not so highly organised. The present system has given those men capable of a high degree of skill the opportunity to use that skill for the larger part of the working day with a minimum amount of hard manual work.

Production planning aims at producing a given product at the lowest possible over-all cost, making possible the payment of a higher wage to the productive side of industry, at the same time giving a reasonable and adequate return to the owners of the capital used in the industry. Just as it selects tools and machinery for their suitability for the performance of a given task in the most efficient manner, so it aims to use human effort in the same efficient manner ; it seeks to use the highly skilled man on highly skilled work for 100% of his working day ; the semi-skilled man on work most suitable to his ability. At the same time it tends to make the work of the unskilled man as easy as possible by the reduction of hard manual labour. Nature made man to suit its own particular purposes, which are infinitely variable. As a consequence, we find the weak and the strong, the intelligent and the less intelligent, those who are manu-

ally skilled, and those whose skill lies in scheming and devising ways and means.

Modern industrial methods tend to make the best use of the natural qualities of the man in his effort to wrest a living from nature with the minimum amount of manual effort. The lowering of production cost, measured in the amount of human effort required to produce a given article, tends to spread the usage of such articles and to bring them within the reach of people who were previously unable to enjoy their use. Remember, the true cost of any article is the amount of human effort required to produce it : tools, machinery, materials, buildings, etc., represent crystallised human effort and therefore come within that definition. Any system which aims at conserving such effort must in the long run benefit humanity.

Planning for Small Volume Production.

In the general sense, the planning requirements for small volume production are precisely the same as for the larger volume production. Design should be checked in the same manner for possible alterations which may have a cost reducing effect. Raw materials may even require more attention than in the larger shop, as suppliers are much more likely to neglect the smaller demand than that of the volume requirement. Operation sequence must of course be decided by some one, whether there be one off, or ten thousand, and it is at this point that one must seriously consider whether existing methods are correct or whether money could be saved by organised planning.

Let us consider the one-off job ana the usual method of handling it, starting from the point where material is available. The shop foreman gets the material and blue print, has a look over the job decides it's a iob for ola Bill on the 10 in. lathe, and gets it sent along to him. In due course, Bill looks the print over carefully and decides he will want certain tools, maybe a special or two. According to the routine of the shop he either reports his requirements to the foreman or proceeds to make or get them made. Bill can then possibly carry out his part of the job to completion. After a little, or a long time has elapsed the shop foreman having had another look at the job, now finished turned, refers to the print which is not quite so clean and legible as it was at first, and decides that Jock on the radial drilling machine can carry out the next operation, but the job wants marking-off first, so down to the marking-off table goes the job. The marker-off, after a look over the job, decides he will have to make a template or two owing to the awkward shape of the job, makes templates, marks job off, and sends it along to Jock

on the drilling machine. Jock in the meantime is well on with another job, so a little more time is lost before he reports that he has completed his operation. Drawing a veil over the remainder of its travels, we get the job finished quite some time after we were due for completion. If in the meantime the job becomes urgent and a promise of delivery is asked for, the foreman, in consultation with one or more of his mechanics, decides that it will take — days to complete. It becomes, together with other jobs of like category, a bit of a nightmare until it is finished. In consequence, it really gets more attention than the foreman can afford to give, and becomes detrimental to other work as well as to the foreman's peace of mind.

Have we really saved money by not planning the job, even if it was only one-off ? Obviously not. The job has been planned just the same, only stage by stage—time has been lost and production has been inefficient.

If a repeat, or a similar job, comes along in a month or two, will anyone remember just how the old job was done, will Bill get the turning to do, or will some other operator proceed to duplicate those one or two special tools Will anyone check up to see if those marking-off templates can be used You all know the answer. Whether the factory be large or whether it be small, and whatever the volume, it is more efficient to sit down, plan the job through all its operations, estimate the time for each operation, on the particular machines through which it is to be routed.

Priorities can be set-up for each particular item, material can be ordered for delivery accordingly, the various items can be planned to arrive at assembly as required, and delivery promises can be made which it is possible to maintain. Special equipment can be made in readiness for use when the job reaches the machine ; such equipment will be official, and be suitably marked and retained in stores against future orders.

Printed forms should be used for operation sheets and, whether written out or typed, should be duplicated so that one copy can be filed in office. Machine load charts are essential if any workable system is to be introduced. The usual type of chart used in non-repetition and small volume shops gives the number of hours available for, say, turning, grinding, milling, drilling, fitting, etc., and records the hours absorbed by work which is to be handled.

Such charts are of very little value, as they do not state exactly when the hours are available. I would suggest that a much better chart, of what I should term the loose leaf type, be designed, using a separate sheet for each machine in the plant. The charts should be inserted in the machine load book, either in the order of machine numbers, or alternatively, according to type, as for instance lathe,

capstan, drilling machine, milling machine (horizontal), milling machine (vertical), and so on, until the whole of the plant is covered.

In one case which could be used as the basis of such a system, though the layout could be modified to suit individual requirements of any given shop, provision is made for the insertion of machine number, description of machine and job number, and the chart is designed to cover four weeks of six working days of twenty hours, ten on day shift, ten on night shift. This should cover the requirements of most shops. The six working days are provided for on the chart, space being left for insertion of date, each day is indicated by a large square, divided up into ten sections each representing one working hour, day shift is shown on top line, night shift on bottom. It is considered unnecessary to make fine sub-divisions, but this can, of course, be arranged should it be found essential. Four hypothetical jobs, which entail the use of 6½ in. centre lathe, 38 in. radial drilling machine, horizontal milling machine, No. 5 B Herbert capstan, may be used to illustrate the working of the system.

We will take job No. 122. The first operation requires a 6½ in. centre lathe, and it is estimated that material will be available November 1. As we are starting from cold, we have no job on that machine at that date, so we proceed to enter the load.

We have 25 pieces to machine at an estimated time of half an hour each, equal to twelve and a half working hours. Normal working day is eight and a half hours, and we do not wish to work overtime or night shift, so we fill in on the chart job No. 122, and draw a red line through the eight and a half hours representing Monday, November 1, and four hours of Tuesday, November 2, and as we estimate that half an hour will be taken up in starting up the job, we carry the line on to the four and a half hour mark on that date.

Our next operation is on a 38 in. radial drill. The time estimated for this operation is ten minutes, with 25 off equals four hours ten minutes. As the machine is vacant, and the job is urgent, we are perfectly safe in starting up the job on the drilling machine at the end of the second working hour on November 2. By that time the lathe will only require two and a half working hours to complete the batch, therefore, we have a safety margin of two hours if we allow twenty minutes for starting up the job on the drilling machine. We therefore draw a line starting at the end of the second working hour of November 2, using four and a half working hours on chart for 38 in. radial drilling machine for job No. 122. Our next operation is on the horizontal milling machine, and the estimated time per piece is six minutes, with 25 off equals two and a half working hours. If we decide to allow a safety margin of one hour on the

drilling machine we can start the job off on the milling machine at the end of the fifth working hour on November 2.

We allow a set-up time of half an hour on the milling machine, so job occupies the milling machine for three hours, finishing at the end of the eighth working hour on November 2. Line is drawn through that period and allocated to job No. 122 on chart for horizontal milling machine.

Final operation is on No. 5 B Herbert capstan and estimated time per piece is fifteen minutes at 25 off equals six and a quarter hours. Allowing a safety margin of one hour, we can arrange to start up the capstan operation one hour later than the milling machine, as the operating time per piece is two and a half times that of the milling operation. Therefore, allowing three-quarters of an hour for set up, the capstan will be occupied for seven working hours commencing at the end of the sixth hour on November 2. No. 5 B Herbert capstan is therefore allocated to job No. 122 from the end of the sixth working hour of November 2 to finish at the end of four and a half working hours of Wednesday, November 3.

Our next job, No. 123, is to handle 50 pieces off. First operation drilling on 38 in. radial drilling machine at three minutes each equals two and a half hours plus half an hour set-up. Machine is vacant November 1 so job 123 can be allocated to chart for that machine for the first three working hours of November 1. Second, third, and fourth operations are all on the horizontal milling machine. The first operation being estimated to take six minutes per piece and the combined time for the three operations seventeen minutes per piece equals fourteen hours ten minutes. Reference to the chart for the horizontal milling machine shows it to be vacant on November 1 for only thirteen and a half working hours before job No. 122 is to be started. Even if we could start up the milling machine immediately we should still be forty minutes light plus one and a half hours required for set-up for the three operations.

No other suitable machine being available, we are in a real quandary. We can either split the batch, wait until job 122 is cleared, or work overtime. Decision, start setting milling machine for first operation on milling machine at same time as drilling machine, allowing for both machines to start up ; we only lose three minutes before milling machine gets away, operating time is double that for drilling, so we soon get well in front on drilling machine.

We allocate job No. 123 to horizontal milling machine for ten hours day shift Monday, November 1, and run on for one hour into hours charted as night shift Monday, November 1, and four hours forty minutes on Tuesday, November 2. This leaves us a margin of twenty minutes before picking up job 122 on the milling machine.

The final operation is to be performed on No. 4 Herbert capstan and takes four minutes per piece, equals three hours twenty minutes

and, as the final milling operation is estimated at five minutes per piece, reference to the chart for the capstan shows that we must pick the job up roughly three hours before the milling is finished if we are to be clear for job No. 122 on the capstan. We therefore allocate job No. 123 to the No. 5 B Herbert capstan as from the end of the second hour of Tuesday, November 2. Job will be finished approximately forty minutes before machine is required for job 122.

Job No. 124 is to machine a simple component which loads the No. 5 Herbert for six hours for first operation, radial drilling machine for four hours, and lathe for two and a half hours. Job can be allocated to No. 5 Herbert November 1, occupying the machine to the end of the sixth hour on that date. It can be picked up at the end of the third hour on the radial drilling machine, finishing at the end of the seventh working hour. The lathe is not vacant until four and a half hours of Tuesday, November 4, have elapsed, and job No. 124 is therefore allocated to lathe, occupying it till the end of the seventh hour on Tuesday, November 2.

We want a job to fill in the unoccupied hours on the 5 B Herbert between the sixth hour of November 1 and the second hour of November 2. If nothing comes up in the meantime, we can slip on that odd job No. 140. This will occupy the No. 5 Herbert for twenty working hours but it is not a big job to set up. We will only load that job tentatively in case another rush job comes along. We therefore allocate job No. 140 to No. 5 B Herbert in chain line for the four and a half hours referred to, then following the completion of job No. 122, we allocate fifteen and a half working hours to job 140 firm, also a further four and a half hours in chain line in case the rush job should arise, in which case we should run job 140 after job No. 122 was completed.

These illustrations give some idea how the charts can be used, but I must state that there may be snags in their use which are not apparent at first sight. The charts have been evolved for the purpose of this paper, in reply to the suggestion to give some consideration to small volume production shops. I know that the weakest link in the control of such shops is the lack of such a chart which, if successful in operation, will make pre-planning a much simpler matter to deal with.

In conclusion, I would express regret that I have been unable to spare more time on the preparation of this paper, and would suggest that the paper be read in conjunction with my previous paper "The Organisation of Production Engineering."

Discussion

Mr. M. C. Park (Chairman): Mr. Jenkins has given us a masterly analysis of the functions of a planning department, and as the discussion is the most important part of any paper we have decided to go straight ahead with the discussion as I have no doubt the time will be all too short.

Mr. Hutchings: Referring to the loading chart explained by Mr. Jenkins, I should like to hear his opinion as to what would happen to the loading arrangements for various machines covering the sequence of operations, if for example a steel casting (one-off) for a turbine cylinder showed after six or eight hours on the first machine, a serious defect which necessitated breaking the job down. How would he reorganise his loading plan to meet that condition?

Mr. Jenkins: When you decided to handle the steel casting, you obviously had in mind a certain plan of operation. Let us say the first operation is to be performed on a lathe, operation estimated to take two days, after completion of lathe operation you would have arranged for other machines to be cleared for subsequent operations.

The casting being scrap after six hours the whole of your planning whether charted or not is a total loss. No system ever devised could overcome that loss. But if the job has been charted, reference to the machine charts will immediately show the effect of the scrap casting on the manufacturing programme and will enable the work to be replanned to make the best use of available facilities.

I do not want anyone to run away with the idea that, because it cannot overcome every difficulty, the machine layout chart should be abandoned even for one-off jobs.

You must look at it from the other angle that if things run right you will save time and keep your machines running to a schedule getting your product out to a known time factor. On the other hand should you get a breakdown or a scrap casting, reference to operation sheet and machine load charts will enable you to see the effect and to replan your work accordingly. Incidentally, I make no claim that the chart illustrated is the best to use for such purposes, it is put forward for the purpose of raising discussion.

Mr. Hutchings: I quite agree that the principle of loading is correct, but if you have allocated work to a machine for a month ahead, which is not unreasonable, and a casting defect occurs, you have got to replan the whole of the work for that machine as well as those allocated for subsequent operations, both for the job

broken down and the jobs included in the period for which a programme has been arranged.

MR. JENKINS : Whether you have planned your shop out on paper or not, you have done a certain amount of planning, and whether you have a chart or not, you have still got the upset, and you do know by looking at your chart precisely what is going to happen, and you can better arrange the other work to run through the machines than by planning the job in your mind. You have got to do some planning, and I certainly cannot see any disadvantage in having planned your work on paper, but I can see definite advantages in knowing what the effect of a scrap casting is going to be, and so fit the hours you have left vacant to the best advantage, and I should advise that you set to work and readjust your charts. It is possible you could replan one job to use the hours left vacant.

MR. HUTCHINGS : Do you not think that in such cases a better method is to give a period in which to finish a certain component. If this is done, say, giving three weeks for a job required in a month, you will get that job in the desired period. My point is that for non-repetition work, planning for a period gives much more flexibility to the plant for rearrangement of programme.

MR. JENKINS : What you are telling me is really just this, that any particular planning is useless and that it is more efficient to take a job ticket out on a time basis, depending really upon having the luck to have a machine open at a given time. That, to my mind, is where the objection to the present system comes in. You may know more about it on production work. I come up against it principally in the tool room. I say I want a given job in a fortnight, we know the job can be handled in a fortnight, and it comes out in a fortnight. But if we make special arrangements and get a job which usually takes longer through in a fortnight, every time I ask why this or that job is not ready, I am told " Because that job went through in a fortnight," and so it goes on, but if you chart your jobs out you can see the effect of anything that comes along, and that, to my mind, is the only way, whether you are dealing in ones, twos, tens, or thousands. Plan your shop and know precisely when a given job will reach the machine. I know that occasionally we shall have to make changes, I know we shall get scrap castings, but I do think to chart your jobs is the best way.

MR. TOOTHILL : When Mr. Jenkins dealt with the layout of the factory I do not think he dealt with the question of machine grouping. There are two main methods of machine grouping, namely, groups of similar machines such as drilling machines, milling machines, capstans, etc., and the alternative method of, say, putting different sets of machines together such as two milling machines, two drilling machines, two capstans, etc., in one group, so as to

get a flow of one particular type of job. I wonder if Mr. Jenkins can say which method he considers the most favourable.

MR. JENKINS : One can only say this, in certain works the method of grouping a bunch of drills, a bunch of milling machines, and a bunch of capstans, and so on, may be the most efficient method for that works in certain respects, but if you have work where you have a regular flow, where you could group two capstans, two drills, two milling machines, and so on, that may be the best method. That grouping can only be planned after you have got and know your job. I think it is useless to recommend any particular plar for a shop unless it is a shop one is connected with. I could say how we lay our own shop out. We have done that in two ways. In certain cases you will find a line of capstans, a line of drills, a line of millers, and so forth, and they are laid down in that way, and their relationship is that the material travels the least distance. If we find that the major number of jobs that come to us for first operation lie on the capstans we should make the capstans the closest point to our material storage. If we find most of these jobs follow on with drilling we should make the drilling machines the next group, and so on, so that we get the most efficient movement of material through operations. In other cases we get a range of jobs of like nature, although differing in shape and dimension, which can be most effectively handled on what we term the group system. The group may consist of, say, three capstans, six drilling machines, two milling machines, and perhaps a plain grinding machine. Naturally, the combinations vary according to the nature of the work. The direction of flow is practically the same on each component, although in certain cases a little back tracking occurs, but in general you get something approaching line production efficiency. It must of course become a question of the particular product you are handling. Where you have repetition work you can usually effectively group machines in that manner. In a general engineering shop I have never seen any better system than the grouping of machines of like nature, but their type relationship could often have been improved to give a better material flow. You frequently can get more efficient operation by grouping machines of like nature, as in the case of automatics or milling machines, etc. It may be possible to allocate two or more machines to one operator. In other cases you can use semi-skilled labour controlled by one toolsetter who is expert on the setting of one particular class of machine. That is one of the weaknesses of the group system of machines of variable nature. The setter has to deal with different types of machinery, and in all probability will not be so expert on given types as the man who specialises in setting that type of machine.

MR. BEDFORD : Mr. Jenkins, with his usual principles of a production engineer, has gone into top gear right the way through.

Listening to this paper I should say the functions of a planning engineer have been very soundly expounded and a principle basis for planning a large or small shop, which can be applied to any particular product we have to produce. I do hope Mr. Jenkins will see fit to have this paper printed so that we can all have the benefit of it, and consider it in view of the various schemes which happen from time to time. On the question of machine maintenance, when he has laid out his shop by means of his dummies, and the work is beginning to flow through, suppose he has a machine breakdown. Whilst he has told us that he has got another machine available somewhere to put in, I can understand that the flow of work is going to be considerably held up, as he has got to have the machine taken out and another put in, and I would like to ask him whether in his plans he has provided for a machine to have duplicates in his planning lines ? The question of machine layout has been considerably debated by questions Mr. Hutchins has put forward, but there are a lot of problems in regard to that. Mr. Jenkins has told us that this particular layout has been produced for the purpose of this paper. I can see quite a lot of trouble if you have loaded all your machines up to the full hours and then your operator stays out or something else happens. You cannot load all your machines up precisely as you want, and there must be some margin and some flexibility, and I would like to hear more as to how he proposes to get that flexibility, and how often he is going to review those charts to bring them up to date to comply with promises which have been made for delivery.

Mr. Jenkins : In the first place, I must say that Mr. Bedford has partly answered his question when he agrees that the chart submitted has been developed for the purposes of this paper. I am the same as Mr. Bedford, I live and learn. I do not suggest that the chart will give a 100% solution to any problem. I quite realise that whether I plan and chart the work or not, I have still got to overcome the business of machine breakdown or the operator being absent. What I do claim is that it is better to know your problem and so be able to systematically check up and determine the necessary action to be taken to overcome it than trust to luck. It may be a question of transfer of labour from a less important job and rearranging accordingly or, in the case of a breakdown, using an alternative machine day and night or Saturday and Sunday, but in any case it will be planned action with a known effect. If the job was not planned and charted the method used to overcome the trouble would probably mean that action of the same nature, i.e. transfer of labour, or the use of an alternative machine, would take place but the effect would be an unknown quantity and much upset and loss would occur. As regards the way we deal with line

production when we get a machine breakdown, obviously Mr. Bedford knows we do not carry many spare machines. Fortunately, at the present moment I have got one or two, in certain cases we must have one or more to slip in in case of breakdown. A breakdown will probably means a loss of thirty hours' work, and that means somebody has got to do thirty hours over the week-end. No system in the world, or any system of economics, will get you out of that difficulty. I think we all have these same difficulties, whether the shop is large or small, and I cannot help feeling that if planning justifies itself in the big shop then it must also justify itself in the small shop. If we save money by planning in the big shop, then we also do in the small one. One of the greatest difficulties both in the large shop and the small shop is justified overtime, and the chart is of great assistance. We all know cases where men have worked all over the week-end, really unjustifiably, just because the foreman thought he would never get that job off in time unless he did. The management say you must not work overtime, unless absolutely essential, and when the manager comes along and says, "Why has this, and this, man got to work ?" with a chart you can say, "Well, we must, you look at the chart ; that job has got to come off here. I have got to run these machines a night or a couple of nights," as the case may be. There is the chart and there is the answer, and the management can only say "Right." If the chart is maintained the management can tell the shop foreman exactly which machines require to work overtime and for how long.

MR. HOLMAN : We have listened to Mr. Jenkins giving us a definite case of the planning department, but I rather think that the system put before us would be one of a super planning department. To my mind, success in industry, when measured in terms, depends upon three main factors, they are—time, price, and quality. If a planning department has to ensure that these factors are being properly attended to, then I agree that they would have to go right through the whole range of the product in some form or other, touching design, material, the method of producing the work, etc., and seeing that all the necessary operations of design, purchase of material, and the production itself were done in time. All these then are functions of a planning department, but doesn't Mr. Jenkins think that how far they go in each particular case depends upon the charter given to them by the works management ? Thus, the quality of the product is laid down by the management which is interpreted for them by the inspectors. I do not suggest that the planning department should or could control inspection but should work in close co-operation. In the same way they should keep in close touch with the designs office to see that the design is suitable for production, and that the materials asked for are such that the plant

at their disposal can work them and still give a satisfactory product. Coming to price, it is a function of the planning department to see that the price allowed can be achieved, and this means that they must be in control, or in close touch with all the operations that effect price, such as cost of labour, and material, machining operations, machines available, etc., and in many cases the question of overheads have to be considered. On the question of time, which is particularly important these days, because if time taken is too long, then the order is lost, or if a delivery date is promised and not kept we have dissatisfied customers. It is, then, a function of the planning department to know exactly how long it should take to produce the product, and to see that the works live up to it. Therefore, it appears that the functions of a planning department depend absolutely upon what the management want their planning department to do.

MR. JENKINS: In the very early stages of the paper I mentioned that one of the difficulties which beset me was to decide what any management would determine as being the planning department functions. What I have attempted to outline is all those phases which I contend come within, or should come within, that range, and then define the functions of a planning department. As a matter of fact, if you had my previous paper you would find that there are a lot of things in that on this same subject which I have not mentioned to-night, and even then it is not complete. One of the things which I have purposely avoided is the control system of material either into or out of the shop. The ideas as to what are the functions of the planning department are variable according to the type and size of the organisation. The larger the organisation the greater the tendency to divide and sub-divide responsibility. This often breeds an attitude tending toward complete segregation expressed in the words, "That has nothing to do with me, that is the responsibility of 'X' department." In the paper you will find I refer to the necessity for the planning department having the fullest knowledge of managerial policy, also for the necessity to check design with a view to modification for ease and cheapness of production. The interest of the planning department in the materials to be used in the manufacture of the product is obvious. The management may employ you to control certain activities which do not include design, material, purchase, and a lot of other activities, but in my opinion that does not justify you in totally ignoring such activities and taking no interest in them. It is quite a natural tendency for one to leave other people to carry, in full, their own responsibilities, particularly if suggestions have been ill received in the past. I have been through that phase myself and felt quite pleased when the other fellow has come unstuck. To-day, I am a little older and a lot wiser. You may make yourself very unpopular at the time, but

it is your duty to open up and say frankly what is in your mind if you do not agree with any proposed line of action, whether it be policy, design, material purchase, or any other activity which may not be directly under your control. Remember, the business you are engaged in represents your living and that of your colleagues from the managing director down to the floor sweeper. Every phase of that business is your business, even down to the selling of the product. One of the things I am always advocating is that people should be frank and fearless in pointing out errors and in stating what they feel to be right. I do not believe in sugar coating the pill to such an extent that it takes a month of Sundays before people realise what your are offering them. On the other hand, if your advice is listened to, analysed, and turned down by your superiors, it is your duty to do your damndest to make their decisions effective.

Mr. Broomhead: It has been my pleasure to have been at meetings where Mr. Jenkins has been chosen to open the discussion at lectures given by such experts as Dr. Schlesinger on more than one occasion, and I think we are particularly fortunate in having Mr. Jenkins as Section President this year. I would like more information about buying the 20 capstans he referred to. Where the planning engineer has an endless source of capital to draw from, and can afford to lay out the planning department in an ideal way, can Mr. Jenkins give us some idea as to what is the cost of this planning department—a proportion with some statistical value or year's turnover, some figure, say, a percentage of direct labour? The next point, what is the co-operation between his planning department and estimating department? Then he argues that the same principle as applied in mass production can be applied in the small shop. What I have at the back of my mind is the construction of parts where your have only, say, 500 off, that may occur several times, therefore in his survey can he give us some idea of percentage of the cost of even that small planning department as compared with the factory's yearly returns for direct labour. In the case of a small shop where he cannot afford such an expensive planning department as he has outlined, does he consider it would be wise and workable to run the planning department together with and in the same office as the estimating department?

Mr. Jenkins: As regards your remarks about the capstans, I do not think you have got what I was driving at. I am thinking of other factories of the same nature and in the same line of business as our own. One in particular I have in mind where a large sum of money is allocated for machinery purchase purposes every year. In that particular factory one finds many different makes of machine of the same category. Capstans of the same size and scope have been purchased from different manufacturers and therefore the

production engineer is in a position to make a definite comparison and analysis of the virtues of the different makes of machine. I have put before you frankly what I believe to be the right policy, and I do know from a long experience that I am not making too big a mistake in keeping to a limited number of types, but I am interested in hearing what other peoples' experience is in the same field. Certain machine tool manufacturers have maintained their relative position in the manufacture of given lines of machinery for many years. I will take one as an instance, Alfred Herbert. In certain lines this firm has maintained a leading position, in other lines one can name other comparable sources. In other cases other manufacturers lead the field. I am speaking from my own experience, I am not certain I am right. I do not contend that I have answered my own question—it wants analysing. In the short period I was in the United States I found that they used machines of the same category made by many different makers. I do not feel that their experience can necessarily fill our bill, as our manufacturing conditions are so different. Most of their manufacture is along specialised line production conditions and does not call for the same degree of flexibility as is required under our smaller quantity production. Nevertheless, any trend in a given direction in that country is always worth deep study and consideration. Now, on this question of planning and the size and relative costs of the planning department. You look at the palatial building I spend my working life in and imagine a staff drawing big salaries playing about with unnecessary bits of paper and drinking tea four or five times a day. Let me tell you our planning department is run on strictly business lines. Very definitely, our people are not overpaid for the important functions they carry out, particularly in relation to production wages. There is one reason for the existence of the department and for the people working in it—it pays a dividend. The size of the manufacturing organisation has nothing to do with the question as to whether you shall or shall not have organised planning. The small shop and the large shop are carrying out the same process. It does not matter whether the product be a roll of toilet paper or an aeroplane engine, whether it costs a few cents or a thousand pounds. If organised planning pays in the big shop it must also pay in the small shop. If this reasoning is accepted, then why not pay one or more men according to requirements to do your planning and record it in proper manner ? You then get the benefit of a man or men who become expert at the job instead of leaving the planning to be split up over every executive and every operator who handles the work. The relationship of planning cost to production labour costs or product value must be infinitely variable according to the nature of the product. The thing that interests me is to make certain

that the duties which each of the different people are carrying out are effective and necessary to the product that is being made. Some one has got to determine what material is to be used, what sequence of operations has to be carried out, what tools are required, and the thousand and one other things which go to make up production activities. Proper recorded planning will ensure that everything is available at the right time and in the right quantity. Does it cost more to do this than to have such things as an operator getting a job finding no tool available, going to stores, getting material cut off, and waiting whilst tool is forged and ground before he can commence work? If directions are not down in writing some one in authority must be consulted and verbal instructions can be misinterpreted with resultant scrap. I have known cases where such instructions have been wrong and when scrap has resulted. The person in control has denied ever having given such instructions, the man has suffered, and a disgruntled servant is the result. Another great benefit of planned production is the fact that repeat orders can be dealt with immediately a check can be made as to the availability of the tools used on the previous lot, and the job can go forward immediately without further trouble or expenditure.

MR. BROOMHEAD: As regards cost of maintenance, have you any percentage, say, your maintenance percentage, against some known figure? Where a works is so well organised they must have some percentage of maintenance expense in proportion to some known figure, and if this percentage could be given as a guide, it would be of great assistance to know whether we were over spending or under spending.

MR. JENKINS: I feel that any comparative figure which I might quote would be valueless, as every plant is a law unto itself, and whilst comparison might justifiably be made between two plants of the same type and age, our own figure would be misleading. You will appreciate the fact that our production capacity has been continually increased over the past few years by the addition of brand new machine tools. The maintenance figures for the new plant would naturally be extremely low, and therefore you would get a false ratio whatever basis might be used. If one looks at plant maintenance in the right light, it can be regarded as an insurance policy; the money expended is an insurance against loss of output due to breakdown. In another sense it may be regarded as paying the doctor to keep a patient in good health, and also to restore the patient to health as quickly as possible in case of sickness. Plant must be kept in proper condition if you are to get efficient and economic operation. If machine tools are allowed to get into a serious state of disrepair before receiving attention, the cost of such repairs will be altogether out of proportion to the benefits

gained, and it might be cheaper to throw them out and replace with new machinery. It is an easy matter to spend £100 on repairing a machine which has been neglected, and yet at the finish have a tool which would not fetch £20 in the open market. Like everything else, commonsense must be used when deciding whether to overhaul or replace worn machinery, and a proper basis must be developed for use as a yard stick for making such decisions.

MR. BROOMHEAD: As regards the co-operation of the planning department and the estimating department, can the planning department and the estimating department be in the same office?

MR. JENKINS: I have personally planned, determined tool lay-out, specified machinery, estimated production time for every process, demonstrated machinery and equipment, and time studied the job and fixed piece work times for production, all from one office. I should not suggest that this is ideal, but there is certainly no reason why planning and estimating cannot be successfully handled from the same office. As a matter of fact, time estimates of a very accurate nature must be got out before one can determine machine tool and equipment requirements. In a small shop the ideal man is one who can plan, estimate times, and if necessary, demonstrate the fairness of such times on a production basis. The one proviso is that he shall be a man with a keen sense of justice who will play fair and, if the time he has fixed is too keen, will admit and correct his mistake. Sharp practice in time study or rate-fixing does not pay a dividend.

MR. FESSEY: I have been in some works where the process engineer does the job, the process engineer makes his own times, and later the rate fixer checked up against these times. In one large works employing over 10,000, the various departments were responsible for their own functions; to put them under one heading would require a "he" man. I would like your opinion as to whether you consider it a better proposition to run these departments separately and independently or under one heading. Just a few observations. Referring to old Bill, Dick, or Harry, I think we should still appreciate some of these old craftsmen who could do a job; no one should forget them, but should have a lot of respect for them, particularly the tool room. Another point is inspection.

MR. JENKINS: When I speak of old Bill, Jack, or Harry, it is in no sense of the word intended to be disrespectful. I have always regarded the old skilled craftsman as the salt of the engineering world. I have stated that the tool room man of to-day is not the same man as those of twenty or thirty years ago. By this I mean that whereas in those days the tool room operator was an all rounder who carried out all operations on a given piece of work, to-day the work is sub-divided and the various processes carried out by experts

in such processes. This does not mean that the tool room man of to-day is an inferior workman; far from that being so the degree of fine accuracy to which things mechanical have now to be made demands that they shall be highly skilled technicians in their own particular spheres, but the sphere of action of the individual is more circumscribed. As regards the question of splitting the activities of the planning department over the various areas, this can only be determined when one knows the conditions under which the factory is to be operated. As I pointed out before, the larger the organisation the greater the tendency to segregate and departmentalise given functions. Where such segregation takes place the success or failure of the whole depends upon the degree of co-ordination which exists between the various departments. Some one must see that all efforts, both physical and mental, are co-ordinated with one common aim in view—production in the most efficient manner As regards inspection departments, I would not call them wet nurses, but I have often called them damned nuisances but, speaking seriously, they perform one function which no one else can adequately perform. When things are going well and one feels inclined to sit back and think that all's well with the production world and one tends to slack off a little, they just come along and spur us all up with "What about this and that? When are you going to do something about improving its quality?"

MR. M. C. PARK: Mr. Jenkins has laid down some of the fundamental points which should be followed in designing tools and equipment, and I am sure they will prove very useful to members. Much of the discussion has been centred around the planning for small shops, and no doubt a good deal of the difficulty of planning in small shops is due to the fact that once planning in one department is commenced it is necessary that the planning should be carried out in all the other departments, as only in this way can planning, say, in machine shops, be effective instead of being ruined by the late arrival of materials or the arrival of defective material, and naturally the planning of the work and machine maintenance is equally important. In conclusion, I think the old saying that if you want a job doing well give it to a busy man applies in the case of this paper. We all know that Mr. Jenkins is a very busy man, and I would like the meeting to show its appreciation of the excellent work that he has done, in the usual manner.

WORKS PRACTICE IN GREAT BRITAIN COMPARED WITH OTHER COUNTRIES.

Paper presented to the Institution, Eastern Counties, and Southern Sections, by W. A. Melhuish, M.I.P.E.

The Need for Comparisons.

AS a small boy, I was instructed, and sometimes forcibly so, that comparisons were odious. Doubtless, those thus responsible for my early training dreamt dreams that I should one day become a kindly country vicar. Even as such, I am not sure that they reasoned correctly, but as a production engineer comparison is surely the standard of all progress. We nowadays reason by comparisons of standard and of performance. That John Smith of Halifax has built a machine at half the cost of my own product, causes me furiously to think. I compare his methods with mine, his staff with my staff, and whan all else fails John Smith's capabilities and brains with my own.

Inside the works we not only compare our standards with known scientific standards, but we compare one worker with another. But our lines of comparison must, if 100% business efficiency be the goal, carry us further affeld. We must compare our men, methods and practice with those operating in other countries. Manifold benefits accrue from such an outlook.

To achieve the best results, however, we must realise that as most factors comprising management have a psychological basis, the executive best suited to appreciate and apply the teachings of comparison, is one with intimate knowledge of men. Indeed, in the writer's opinion, no executive can claim to understand control of labour, unless he has had first hand knowledge of different types of workers, men from different districts, and even of different countries. Those who have attempted to control Australian workers doubtless appreciate this point. Was it not due to this recognition of the value of comparison that the International Management Institute was founded at Geneva ?

Having thus explained the viewpoint which prompted the construction of this paper, it is intended to touch lightly upon several factors of works practice, which can, it is felt, benefit considerably from an international comparison.

Ipswich, October 7 ; Southampton, October 20 ; Leicester, November 18, 1937.

Definition of Works Practice.

Let us first of all consider what we mean by the term "works practice." In any technical college syllabus, we can generally find a course entitled "Shop practice." By such is meant that the student will receive training in machine work of turning, milling, etc., and of bench work in the best known practice and with the latest precision tools. Good though this may be, it is only part of works practice, because surely the methods whereby this actual manufacturing is first determined and then controlled are equally as important as the actual work itself. The problem facing any business is not, I believe, so much a question of using the best known practice in manufacturing, but the best methods of manufacturing control and management.

The old fashioned machining process, if still in use, causes the machining time to be longer than it should be with modern tools, but the old fashioned method of production control will, in comparison, loose the business many times this amount per annum, and therefore is the greater evil of the two. Although technical colleges have realised the importance of teaching factory organisation and production engineering, when the two factors of shop and production control are combined in one syllabus, a big step forward in the training of future production engineers will have been accomplished. Recognising the importance of both these factors to a production engineer, it is proposed first to compare manufacturing control in a number of countries and then to likewise deal with shop practice.

Manufacturing Control in Great Britain.

Years ago it was the practice of the managements of engineering companies to discharge boys upon the completion of their apprenticeships, but to re-engage them as journeymen as soon as they had proved themselves elsewhere. The principle governing this action was one of comparison—the judging of the budding journeyman with the craftsman at large. Probably much of the present day loss of craftsmanship is due to the fact that we no longer adhere to this principle.

Anyone who has had experience of consultant work in the field of management engineering, knows full well the colossal differences between many firms in this country. Such differences are not only apparent between the mass production firm on the one hand and the jobbing shop on the other, but even between any two firms of like nature.

The Mass Production Concern.

The large mass-production firm manufacturing a single product is probably the one type of organisation which has achieved the nearest approach to uniform method, but even here, there is con-

siderable variation in works practice between companies.

It must not be assumed that every large organisation is a second Ford Motor Co. or Austin Motor Co. Indeed, there exist in this country large organisations whose methods, when judged by the fact that their resources are manifold, are primitive to a degree. The author has in mind one large organisation which, by reason of the nature of its products, is in a most enviable position from a production engineer's point of view, yet languishes in most haphazard manufacturing methods while its directors spend their time bemoaning the high costs of production as compared with those obtainable overseas.

The reason is not far to seek. No production engineer is employed, the works is controlled by a works manager who, although a clever designer, is by far the worst manufacturing engineer it has been my misfortune to meet. Consequently the drawing office, which is the "brains" of this organisation, issues no manufacturing instructions to the works, but allows chargehands, who have spent their lifetime with the firm, to decide "where and how to make" just as they did forty years ago. God forbid that this company's elderly storekeeper should die suddenly—because the entire records of overseas shipment of spares are contained in a notebook which never leaves his person.

It was a director of this company who, proudly showing two elaborate drawings to illustrate the cleverness of his draughtsmen, was greatly disconcerted when it was quickly pointed out that the second drawing was a replica of the first, except for a deeper boss on one portion of the mechanism—and therefore considerable time had been wasted in producing the second drawing because the first drawing could have contained a note to the effect that, when making part II, repeat the mechanism shown, only make boss marked × such a size.

Probably much of our loss of efficiency in large mass production concerns in this country compared with similar companies overseas is due to mis-placed personnel. We have yet to discover the secret of finding the right man for the right job. Our American cousins have it—why cannot we? This mis-casting of personnel is most obvious on the managerial side where we still bow to the old school tie.

The Mass Production Firm Manufacturing a Variety of Products.

Managing this type of business is a far different proposition than dealing with a single product, because the multiplicity of activities makes production control far more complicated. It is in this type of company in Great Britain that we have so much to learn from comparison. Broadly speaking, companies of this type can be

placed in one of two categories: (*a*) Those who adopt the principle of self-contained departments—building, as it were, a number of separate works, one for each product; (*b*) those who try to mass produce all products simultaneously.

The former do to some extent achieve mass production, but they do so at tremendous expense, because the majority of their staffs are duplicated department by department. Where it is attempted to produce simultaneously a variety of products, overheads usually rise to tremendous proportions, and confusion is the rule rather than the exception. Later in the paper it is intended to compare overseas methods of control in this type of organisation.

The Jobbing Shop.

At one of our meetings, I once heard a questioner say he would not under any circumstances use charts at his works. I did not get a chance to have a chat with our friend, but I am pretty sure that he came from a jobbing shop. Whether he did or not, he was totally wrong in his views. I mention this because some of our jobbing shop engineers have an inferiority complex. Indeed, they must have something the matter with them because a comparison between any two general engineering works in this country makes one wonder what engineering is.

Surely we must agree fundamentally that there is a right and a wrong way of doing a job, that whether you are making 10,000 parts or 10, you have to pre-determine the best way to do it with the means at your command, and that whether the order is large or small, efficient control is necessary to achieve quick deliveries at a satisfactory price. One often finds two general engineering works making the same article and for identical parts, one concern uses castings and the other bar metal. Why?

Manufacturing Control in South Africa.

In a new country one has to expect a stage of transition. To some extent this is true of South Africa, as witnessed by the large plants at present being erected in the country, and also those of comparatively recent origin. In some of these large concerns, founded on American capital, one does find scientific management, although even this is discounted by the lack of the right type of executive. Naturally, for obvious reasons, an overseas company has to use South African labour as far as possible, and seeing that few South Africans have had experience of scientific management, the general efficiency of the company suffers. Normally, this would be overcome in time, but one feels doubtful as far as South Africa is concerned, owing to the disinclination of people out there to profit by other countries' experience.

For instance, a friend of mine offered to write a series of articles

for the South African Press on time and motion study, industrial psychology, etc., but the offer was rejected, as it was felt that the articles would not be understood and, more important still, nobody would evince the slightest interest in such topics.

Racial antagonism is also a drawback to engineering progress in South Africa. Only too often bi-lingualism is the deciding factor in placing a high executive. Excepting branches of overseas organisations, the rest of the engineering works in South Africa are jobbing shops of the worst degree. The Rand, and especially Johannesburg, bristles with hundreds of engineering works, the majority of which would be condemned by any factory inspector in Great Britain.

Working for the gold mines of the Transvaal, they are really maintenance engineers—profitable, because wealthy gold mining organisations will pay almost any price to get a job done quickly. It would probably be a blessing in disguise for South African engineering if the Rand gold mines ran dry.

However, to give credit where it is due, I must admit that in a works in South Africa I saw a most efficient progress system. Works orders in the form of tear-off slips, similar to those used in our boot and shoe factories, were posted daily on a blackboard in each section. After each operation was completed, the appropriate section was detached and forwarded to the office. By this means a full day's work was allocated to each section of a department, the correct sequence of orders to be undertaken was ensured, and the office could instantly tell the position of all orders.

I found one really well organised concern in South Africa, and strange to say it was a French company. The organisation of this company was superior to any firm of its size that I know of in Great Britain. Producing small patent parts the works were splendidly laid out. Some advanced French time study engineer had doubtless been responsible, because the colour scheme and lighting arrangements of the various departments were far in advance of anything in this nature yet accomplished in Great Britain.

Knowing that the company made enormous profits per annum, I probed deeply to discover the reasons. This is what I found: (1) Production control similar to the average concern in Great Britain; (2) tooling methods comparable with the best in U.S.A.; (3) scientific lay-out, lighting, and colour schemes superior to anything in my knowledge accomplished elsewhere; (4) the most contented working force it has been my pleasure to meet.

Manufacturing Control in Australia.

Trade unions and other labour organisations are the drawbacks here; it is they who manage businesses. To those executives

harassed by labour troubles, I would say "Thank God you are not in Australia." Time and motion study is little used, because even piecework will not be tolerated by Australian workers. As these people individually reserve the right to decide how a job should best be done, planning is somewhat at a discount. Attempts made to plan a works systematically frequently end in a strike. Such conditions do not tend to breed the right type of executives. On the other hand, the great versatility of the average Australian worker gives a decided advantage which is denied to many of our own businesses.

The majority of Australian engineering workers are not simply fitters or turners, or planers or borers, as the case may be, but are equally efficient in several of these branches of the trade. In engineering in Great Britain, excepting probably in the very small jobbing shops, a tradesman is either a fitter or turner or a machinist, and he specialises upon one, without thought of the other. It is not the worker's fault, our mass production specialisation has made him so.

Are we acting wisely in rigidly adhering to this sectionalising? To those who argue that modern business makes this specialisation essential, I would point out that in every aspect of works organisation we allow for "flexibility" and yet ignore this most important factor in connection with probably our greatest concern, that of labour. The present shortage of skilled workers such as "tool-setters" I believe endorses my point of view.

Engineering organisation in Australia is hampered by being forbidden the use of female labour. Mentally recalling the application of the Coventry female capstan operators, one can sympathise, but on the other hand, remembering the female bench workers to be found up and down Great Britain, one is not so sure.

If Australia diluted its labour would it be better off Advocates of cheap labour are faced with tremendous overheads in the form of inspection staff. Inspection in Australia is the responsibility of each worker. We have something to learn here. Why pay skilled rates and then incur an expense for ensuring that work is properly done?

Manufacturing Control in India.

India breeds the ideal executive. The "managing agent" principle of control is no doubt responsible for this. This principle is, as far as my experiences carry me, peculiar to British India, and not to be found in any other country where manufacturing engineering is undertaken. It originates from the days of "Clive" when the merchants, in the form of the East India Co., ruled India. The course of time has lessened the extent of the powers of the merchants but Indian trade, external or internal, is essentially still in the

hands of a group of merchants known as "managing agents."

These large organisations, representing as they do in India, British, American, and Continental interests, not only act as traders, but as representatives or managing agents of widely different activities. For instance, one large company of managing agents in India controls and directs four large tea plantations, a large electrical engineering works, a huge galvanising plant, several paper mills, banks, and a variety of other interests. With such varying activities, they are forced to rely on a small team of managers, each with his head office in the main head office building.

Due to the high salaries paid to Europeans in India, these managers believe in keeping European staffs at a minimum. To do this they must secure works managers and other executives who are highly versatile and capable of assuming many responsibilities.

As there is no better teacher than responsibility, the young executive in India, probably just out from home, is completely thrown on his own resources, and either sinks or swims. Many fail and are sent back home, but those who survive this hard test rapidly gain knowledge and develop to a high degree the qualities of a successful administrator—confidence, initiative, and personality. I know of no other country where young men are given such opportunities as in India.

The extent of the responsibilities to be faced can be visualised when it is known that in a large works in India employing 1,500 natives, manufacturing electric fans, switchboards, ironclad cubicles, tea machinery, and general engineering, two young Englishmen were completely responsible for the entire manufacturing, design, costing, outside erection, and a great part of sales activities.

Manufacturing control is an entirely different proposition here than elsewhere. One cannot deal with illiterate natives as with labour in the English concern. For instance, where we at home can evolve, say, a suitable stock recording system, and arrange for storekeepers to work to correct classification and control maximum and minimum stocks by perpetual inventories, this is not good enough in India, because the storekeeper very often cannot write or check quantities, and even if he could, he would probably forget to record figures on the stock cards.

One has to try to make things fool-proof everywhere. We did so by storing in sequence and by making stocks self-evident. Our first attempt at progressing was ineffective, as we often found the progress man sound asleep or goods progressing into the native bazaars. Our method was to fix rates and refuse to pay anyone until work arrived at the desired stage, as well as imposing fines for faulty work. Rather harsh, no doubt, and yet could we not do with some such system in other countries besides India

Manufacturing Control in U.S.A.

An American business man once spent twenty minutes or so telling me he was too busy to see me, when my business could have been finished in five minutes at the most. However, despite this and similar Americanisms, I have a high regard for American executives. They know what they want and how to get it.

Comparing American manufacturing control methods with the methods operating in the average business in Great Britain, I am of the opinion that in the following factors we suffer in comparison : (1) Planning (what to make, where to make, when to make) ; (2) production control by sales policy ; (3) selection and training of staff ; (4) manufacturing costs.

Some concerns in Great Britain seem to have arisen because two or three men with money have decided to promote a business, have formed a company, chosen the biggest shareholder as managing director, engaged a secretary, acquired premises not too far away from their immediate social circles, bought plant upon the advice of advertisements, and engaged sufficient labour to work it. On the other hand, business promotion in America appears to be the result of sound deliberation and pre-determined action.

The possible market for their products is the first factor considered then the ideal site, and then specialisation. Such consideration is not confined to the promotion of new concerns ; Americans are eternally seeking ways and means to better their existing plants. That British interests do not do likewise is witnessed in the ghastly plants to be found up and down the country, and especially in the Black Country. That we do not appreciate specialisation as the Americans do is obvious from the large number of engineering works in Great Britain which carry white elephants in the form of foundries and automatic machine shops. The Americans realise that a man responsible for a foundry and nothing else, is more able to specialise and become more efficient than his counterpart who in addition to foundry control, is responsible for many more manufacturing activities.

As referred to earlier in the paper, the type of organisation in Great Britain which is concerned with the manufacture of a variety of products, should realise that specialisation is sound production control. It should take one of two forms, specialising to the extent of using separate plants for separate products, or components, or specialising to the extent of eliminating unsuitable products, unsuitable because of not being efficiently equipped for the work to be done, or because the manufacturing of a given product would clash with another.

American manufacture is pre-determined to a definite sales policy. An organisation not only trains its own salesmen by teaching them

the best points of the product they are to sell, but gives them also thorough instruction by means of samples on the weak points of competitors' models.

If there is one thing we ought to copy America in, it i the selection and training of staff. The aim of our employment managers seems to be the vieing with one another in writing queer advertisements for the Press. How many holding these posts are really qualified ? I know of one employment manager who was previously a scenic artist, and another a journalist. True, the journalist may have one of the qualifications of a successful employment manager, a knowledge of men, but what of his knowledge of the trades ? Very few of these officials appreciate industrial psychology. America has made a science of selection of staff, their vocational and intelligence tests judge an applicant not for anticedents, culture, school, or for being a nice fellow, but for the intelligence and peculiar talents required for the job in question.

American manufacturing costs per unit produced are the lowest of any manufacturing country, and yet they pay the highest wages. Surely we must have something to learn from this. In the main, they achieve it by greater application of the line system of manufacture, by the utmost use of jigs, fixtures and tools, and by understanding industrial psychology to such an extent that they choose the right man for the right job and secure the " team spirit " amongst workers.

Manufacturing Methods.

Appreciating that one could discuss this topic *ad infinitum*, and that no rigid argument for or against any particular process could be substantiated unless a wide range of articles to be manufactured were carefully dissected and each operation to be performed separately discussed, it is proposed to review manufacturing methods in a number of countries on the basis of : (*a*) What to make ; (*b*) how to make.

What to Make.

Almost every company periodically arrives at a position when the question of " What to make " assumes paramount importance. The frequency with which it occurs largely determines the soundness of the organisation and the amount of " vision " held by its directors.

In the case of many companies in Great Britain such frequency is due to the antiquated designs of the products. We still have many firms in our midst who are run by the inventor of fifty years ago, men who refuse to understand modern progress and fondly cling to their " first loves."

On the other hand, we have the seemingly modern go-ahead concern who so often changes its mind with regard to design that

standards do not exist, nobody dares to concentrate on improving a part in case the next change may find it obliterated, and production becomes a farce. It is due to this state of affairs that in the question of design we are so far behind America. In case any one of you may immediately recall the fact that Great Britain holds the majority of records for engine performance, etc., I would hasten to add that I am concerned with the smaller details of design, those points which bring about the need for production engineers, the details which largely determine the ratio of manufacturing costs.

Let us consider an example. Take for instance the ordinary gusset plate used on fabricated work. The English designer produces a most elaborate design with beautiful flowing curves which, whilst doubtless artistic, incurs heavy machining costs in its production. The American, however, realising that the part cannot be seen in the final construction, and artistic appearance is therefore of no value, produces a similar plate with equal merit of performance in a series of straight lines, so that a sheet of metal can be quickly guillotined to the designed shape.

Concentration on design is badly needed, especially that aspect of design which governs actual manufacturing. As a case in point I would cite the experiences of a large electrical company. This company in one of its products used a specially heat-treated metal cam. Its use presented many difficulties. First, there was the fact that the steel casting suppliers required a period of four months from the receipt of the order before commencing deliveries, secondly, owing to the chilled nature of the metal, machining was most difficult, and lastly but by no means least, on an average 60% of the castings were rejected during machining operations owing to porous metal, etc. As the company did not in any way cater for research, the various departmental heads had for months, aye even years, battled with the problem of how to improve either the machining processes or the casting itself. When eventually research was catered for, the first action of the new department was to prove conclusively that, with a slight modification in the design of the product, the use of the steel cam was unnecessary.

Design can benefit materially from periodical international comparisons. We must, however, guard against the evil of becoming just copiers. That is what happens in the Indian owned workshops in India. Here, if say a pump is required, they simply buy a second hand one, pull it to pieces, and copy every detail, even going so far as to use the existing parts as metal patterns for the foundry.

Excepting probably in the case of very large companies in Great Britain, " What to make " evolves round the question of " Standard lines." Far too many companies indulge in cut-throat competition with each other instead of concentrating on improving and estab-

lishing standard products suitable to facilities at their command.

We have not overlooked the fact, however, that as nearly all companies have occasion to undertake varying degrees of jobbing work—we must plan to control it in an efficient manner. Comparison has taught me that it is a much neglected side of production.

How to do it depends upon the ratio of jobbing work to standard orders. If small, certain machines should be allocated, if large, a section or a department should be entirely given over to work of a jobbing nature.

The question of "What to make" should be largely determined by the cost office. Members of the Cost and Works Accountants' Institute can pride themselves that they have decided for many concerns the vital question of "What to make." In one case, a large company producing a variety of products had for many years shipped a certain class of goods to America under the firm conviction that it could sell in the States cheaper than the Americans could manufacture until a cost accountant was engaged, and it was proved that it was more profitable for the company to give up this type of business as the losses incurred on this work seriously jeopardised the economic stability of all the company's products.

How to Make.

This is the production engineer's job, and yet it often happens that circumstances beyond his control forbid him doing what is best. He is, in this country, for instance, often expected to work miracles in some old fashioned machine shop. Thank God that the trade depression closed some of them. I am quite sure that our Institution has done much in the last few years to educate employers to the realisation that efficiency is essential in the shop which sets the pace for the rest of the factory, but even yet our machine shops are a long way behind those in the States. Our layouts and material handling devices are definitely inferior. True also is the fact that we still cling to standard machine tolls, and do not make the utmost use of single purpose machines.

It may be argued that the use of single purpose machines is only possible on full exploited mass production. True, but does not mass production arise out of "vision"—a virtue often sadly lacking in British enterprise?

I would compare the creation of a new product in an English and in an American works. I have in mind an electrical instrument which I know was produced in both countries in almost similar forms. The English company designed its product, and after waiting for a considerable period for the managing director's O.K., eventually had an instrument maker produce a sample part by part. The workmanship was splendid—so the instrument passed the final tests. Orders were then given to the production department

to manufacture 1,000 off. Determined to maintain the quality of the sample the production department had all components rough machined in the machine shop, leaving a tolerance for the instrument makers to finish to size. The 1,000 were finished satisfactorily and came out at a works cost of £9 5s. each.

The American procedure was slightly different. The designs, after being approved were handed over to the planning department and an estimate called for as to what price and in what quantities could the product be manufactured.

Layouts for each component part, together with the necessary tools to give output and accuracy in production were constructed and the whole procedure was thoroughly planned like any production order. Due to the advice of the planning department, an order for 2,000 was put into the shops. Final figures showed that the product had been satisfactorily produced at a cost of £6 per unit, including cost of tools. There is, however, a sequel. Twelve months later management engineers were called in to the English concern to reorganise.

Experience has forced me to the conclusion that actual manufacturing methods in Great Britain suffer in comparison with Continental and American methods—not because we don't know the best way of doing a job—I would back most British production engineers to take a drawing of any machined part or mechanism and define the correct sequence of manufacturing processes—but because our inferior planning activities frequently force us to adopt a sequence of operations which we know to be incorrect and contrary to best practice.

We often define processes on a part in the nature of turning, shaping, drilling, and then in actual manufacturing do turning, milling, drilling, or even just turn and allow bench workers to finish to drawing. These alternative processes, which play havoc with our works costs, do not arise because we have too much work on hand, as some would argue, but because of lack of foresight and system in planning.

I once placed a drawing of a gearbox before an English production engineer, an American production engineer, and an Italian production engineer, and asked each in turn to state how they would manufacture 1,000 off. Replies were identical except that the American commenced by saying "Why only 1,000 ?" and the Englishman safeguarded himself by frequently saying "Provided I could rely on good castings, I would do so and so." There is great truth in that last remark. Foundry practice in Great Britain is exceedingly poor and the cause of much of our inferior shop practice.

"How to make" involves two important factors: (*a*) Quality; (*b*) costs.

In the former we definitely score over any other country where hand labour is concerned, because British craftsmanship has no parallel, but we cannot produce cheaply.

We may appreciate time study, and to some extent exploit it in an attempt to lower costs, but we are lacking in driving force. Let me hasten to make myself perfectly clear. Although I am a sound believer in efficient organisation, I also place great store in the personal element. However efficient our organisation may be, however thoroughly we plan, however good our tools may be, despite what steps we take to progress the work through departments, we often fail because of lack of driving force. We have need of men with personality and driving power to force work through to completion. It is so in my own works, and I know it applies in many others.

The American production engineer beats us not simply because he has organised better than we have, but because he backs up his planning with a driving force which produces results not within the scope of pre-determined planning! His is the success which rightly falls to the leader, the man with personality and initiative. We are, I believe, apt to think of American push in the light of a music hall joke, and thereby fail to consider if it is a reality or not. No. The Americans may brag, but they have something to brag about—they get results.

The other day, when an American production engineer called at my office, he was greatly upset that, although dealing with several firms over here, he could not get things done, because managements are too lenient, prepared to say, "Well, he's a nice fellow, and he's been with us ten years now," instead of refusing to countenance blunders and firing those responsible, as would be done in U.S.A.

Tools.

We tool not only for accuracy but for cheapness as well, so that the amount we are prepared to spend on tools decides the price of the unit produced. It is not sound policy, however, to tool always to the limit. In fact, more contracts are lost because of excess tooling charges than for probably any other reason.

I am of the opinion that A.I.D. practice of requiring a separate quotation for the tools required to produce the work on every contract is an admirable one, and could well be adapted with advantage to most classes of commercial work. In case such remarks may appear to have very little to do with the question of "What to make" I would stress the fact that I definitely consider that our tooling practice is often wrong, simply because we do not view standard work in the light of new work for which we are competing in the open market.

If we periodically reviewed our standard products and con-

structed an estimate just as though we were quoting for a contract, we would probably be amazed at our machining costs, and be forced to review our tooling methods. Similarly, we would doubtless find much scope for reduction of assembly costs.

It has often been advocated that a production engineer should periodically paste on his office wall a sample of every printed form used in the business. Would it not also be wise to similarly review our tool stores ? If we did, we would doubtless come to the conclusion that we ought to go to America, or indeed almost anywhere else, in order to learn how to make high class jigs, tools, and fixtures. The drilling jig which necessitates several minutes for manipulation and seconds for drilling, is quite common in Great Britain.

We are constantly learning about actual manufacturing methods. In fact it is true of all countries—but the danger I see in Great Britain is that we are apt to hail the introduction of some new method or process and instantly put it into operation without carefully considering its suitability to meet our own peculiar requirements. I refer, for instance, to broaching. Many firms in this country went right over to broaching practice and made literally hundreds of costly tools without paying much thought to what repetition work was on hand or, indeed, likely to be in the near future.

In conclusion I would stress that our outlook should always be to find out " How the other fellow does it " whilst at the same time remembering Henry Ford's advice that " However much away from practice it may be—if it will do your job—do it."

Discussion—Eastern Counties Section.

A general meeting of the Eastern Counties Section was held in the Lecture Room, the Central Library, Northgate Street, Ipswich, on Thursday, October 7, 1937. The President, Mr. G. C. Detlefsen, was in the chair, and there were 85 members and visitors present. The lecture was given by Mr. A. W. Melhuish, and was entitled "Works practice in Great Britain as compared with other countries."

Mr. G. C. Detlefsen (Section President) said that the background as to how American methods started is very often forgotten. The average workers in the heavier industries were Russian, Polish, Scandinavian, and very few English and, therefore, very often the management had to issue instructions through an interpreter. Production was carried on by iron rule methods, and the worker had to do as he was instructed. The present American methods had evolved from this background. In England we all spoke the same language ; the social status of the worker is very much alike. The relationship between employer and employee was more kindly and sympathetic. The men knew their business, and there was no necessity to drive them. Mr. Detlefsen asked the lecturer whether or not it was his opinion that England is not now adjusting herself to the combination of the qualities of the English workman in relation to good scientific management. The speaker was of the opinion that England was moving very rapidly in that direction.

Mr. Melhuish thanked Mr. Detlefsen for his explanation as to how American methods evolved. He thought the explanation was quite true, and mentioned that when in India he was also faced with the problem of making the workmen understand what was required. He stated that he was of the opinion that England was moving rapidly in the direction of applying American methods, and that these methods are being applied in hundreds of firms in this country.

Mr. Diggle : Some firms may attempt to produce certain articles on mass production methods although the market is not stable. In planning, everything is thought out for the best and cheapest method of production. You run a certain staff of workers dealing with big output. What would you advocate doing when sales fluctuate to a great extent ? Would you continue on the same mass production methods, or go back to another method of production and have workers standing idle ?

Mr. Melhuish : I think our friend has mentioned possibly the greatest snag in mass production. I know five companies which

have been faced with this problem. My company advanced the idea to them that they could not allow their output to fluctuate to any great extent. It was lack of vision and bad policy to make 1,000 articles one month and 10,000 the next month. The principle to adopt was to manufacture in batch quantities and stock. The man who is manufacturing small parts and is faced with an output fluctuating over a period must, through the cost office, construct a budget whereby he can say that over the whole twelve months the output will be such a number. We make a great mistake by taking our output monthly when we should take it on years. Say in the past our sales have averaged 15,000 per month. If we make 15,000 one month, 15,000 the next, miss three months, and then make another 15,000, we will lose. We must take an average over a period and plan, the planning being done in conjunction with the production engineer, cost accountant, and sales manager.

MR. DIGGLE: I quite appreciate what you have said. Sometimes it is not possible to do that. One may say you produce so many over two years. Suddenly, there is a huge demand at a very short delivery; this condition may last, but you do not know when it is going to fall off, and a manager can be faced with the fact that he cannot budget correctly as you suggest. For instance, a firm has been on a budget quite a time and they review their figures. Figures show that for the past six months they had been selling five articles per month but, the six months previous they sold 50. Now, that is the point. Difficulty in forecasting correctly, and at the same time, base production methods on mass production methods.

MR. MELHUISH: Some time ago I went into an electrical works. This company was in a hopeless state trying to give deliveries required. I claim that the first essential of the planning engineer is to decide what to make. He must have a chart of his machines in the machine shop showing when every machine is booked up to. If output was fluctuating due to certain orders just received, I should say we cannot give big delivery dates because we have not got the articles in stock. Therefore, we are faced with what to make. Machines will only turn out twenty-four hours a day. The only alternative is to work shift work or overtime, or if not this, sub-let. What to make. Whether we could make does not matter. Have we the capacity? If I was faced with the output of one product, and to do this I was forbidden to turn out all parts, I would sub-let to suppliers outside the works.

MR. DETLEFSEN: It was mentioned by the lecturer that a colour scheme was employed in a South African factory, and I would like to ask Mr. Melhuish if he could give any information with regard to this.

MR. MELHUISH: I am not an authority on colour schemes, but

I do know that light colours are brighter to work in than dull colours. In the particular case referred to, the walls were painted light yellow and light green. The first impression was that one could work more efficiently in such an atmosphere. They have gone further than this and have even painted shafting, using a dark green paint for this purpose. The floors were dark stained and white road lines painted to the various departments. I think that in engineering to-day, to take a highly mental and highly strung man into a dirty factory and ask him to be efficient, is asking too much. Whether the colours mentioned were the best I don't know, but I felt that I could work at 100% efficiency. The Institute of Psychology says that firms who have colour schemes generally chose light yellow and light green.

Mr. J. B. Webster: In manufacturing a number of articles comprising a range of sizes, where one size is to be manufactured in large quantities and the other sizes not so great, would you recommend mass producing the one size of the large quantities in a separate factory and keep the other sizes in a jobbing factory?

Mr. Melhuish: This, I think, depends on designing. In one shop they had a range of sizes and were faced with this difficulty. The first thing we did was to thoroughly design, and found we came to a common manufacturing scheme for the whole lot. The best method is to make the largest sizes on mass production and stock, draw from the stock and machine down again for the smaller sizes as required, and for certain articles unlike in design, treat as a jobbing shop. This method has been used with great success.

Mr. Rackham: What is your opinion on the matter of doing mass production and jobbing work on the same job? Would you advocate separate shops or mass production on one side of the shop and jobbing work on the other?

Mr. Melhuish: Some time ago some friends and I were interested in putting an article on the market. This point was the biggest of all. We had drawn up a design of line production and also a layout for the ordinary jobbing shop. We came across a company doing both classes of work, and we came to the conclusion that we could evolve a system whereby jobbing could be done on the same lines as the mass production. We tried it out and it was very successful. We could pass the articles down the line. If you have a conveyor you must divert certain machines in the line.

Mr. Diggle: We found after experimenting that it was much better to have a separate shop. One part wanders through and you don't know how much it is costing through delays in production.

Mr. Melhuish: If the quantity is small it could be done on a separate machine, but if a large range was being dealt with a different shop should be used.

MR. BIRTEWER: Is there any question of sentiment in American business methods? Is it customary to hold a committee meeting before any decision is arrived at, or can one man say do this or that, and get on with it?

MR. MELHUISH: The curse in Great Britain is the sentiment in business. There are many young men barred because of sentiment. Brains and ability should always count; once you lose brains and efficiency you don't fit. From my knowledge of the States, it is my opinion that there is no sentiment. A man is not pensioned off, he is just put off because he cannot hold his job down. Also in Great Britain we are cursed with committees; this does not apply to the States. The production engineer is the head man and works in conjunction with the cost accountant and sales manager, under the managing director.

MR. DETLEFSEN: There are good employers in the States, and bad. There is as much sympathy in America as in England, but there is always the tendency in England of advantage being taken of the sympathy between employer and employee.

MR. LEGGETT: It has been my privilege to go through several shops in America and Germany and, as far as I saw, there was certainly a certain amount of sentiment. I always found sympathetic consideration towards old servants. There is one thing which I have always noticed in England and that is, the great lack of planning. On behalf of the members present I propose a hearty vote of thanks to the lecturer for his extremely interesting talk.

MR. RACKHAM: In seconding Mr. Leggett's vote of thanks, I would like to say that this has been the most interesting lecture, in my opinion, since the inception of the Institution of Production Engineers in this centre.

Mr. Melhuish suitably replied.

Discussion—Southern Section.

MR. DENNY (Section President) thanked Mr. Melhuish for the very interesting paper presented to the meeting. He would like to say, however, that he felt that, generally speaking, Mr. Melhuish had passed a very big wave of depression over our manufacturing methods in his comparison between ourselves and America, and he thought that to be fair to ourselves we ought to consider that it wasn't always the production engineer who was to blame, but the policy of the managing directors. Every production engineer would probably like to make 2,000 instead of 1,000, but they were not allowed to do so. He, therefore, did not think that production engineers were to blame in that direction as, if they were given the same facilities or the same chances, the comparison would not be so odious as that which Mr. Melhuish had made in the early part of his lecture.

There was another interesting thing which Mr. Melhuish had mentioned when he was talking about Australia, and that was inspection. Mr. Denny said that although he had to mention the subject the other day in the works when they were talking, or rather they were complaining about inspection, and he had said that it was the theory of their principle that they shouldn't want an inspection department at all, we know that in practice we had got to have them.

There was one thing he would like to ask the lecturer about, and that was the question of costs. He had noticed that it had been left out practically all the way through, and in the comparison between the various countries and how they did the work nothing was said about how costs compared. Mr. Denny said that he would like the lecturer to say a few words on that subject—if he was able to compare the manufacture of our country with Australia, South Africa, and India. There was another thing, and that was the question of the employment manager. Well, once again he thought that the lecturer's conclusions were very depressing, but he could not think of any organisation who would allow an employment manager to take on men willy nilly. He knew they would not in his works, and he could not think of any works that would allow it, but the lecturer's experiences had been so varied that he seemed to have discovered organisations who had done those peculiar things, and he thought that the particulars in connection with this point were of very great importance, and more the exception than the rule.

MR. MELHUISH said that in an attempt to reply to the questions raised by Mr. Denny he would take the last one first, viz., employ-

ment managers. He thought, if Mr. Denny would pardon him saying so, that we were always apt to strike a comparison from our own works. Mr. Denny might have a very capable employment manager, but assuming that this was so it did not mean to say that the majority of the companies in Great Britain had. He had encountered worse employment managers in Great Britain than in any other country; men who had been badly chosen, and therefore had not the necessary knowledge. He could name one of the biggest organisations in Great Britain, not very far away from London, who had one of the worst employment managers it had been his misfortune to meet, and in his opinion he was the cause of a great deal of discontent and trouble in the works. How a management of this company's description could tolerate such a man he did not know. He was definitely not the type of person to choose the right man for the right job.

Mr. Melhuish said that he would put it another way. Say they wanted to engage a young man to start on the progress staff. Well, an employment manager should first of all be competent to judge that it was a special job requiring special talents and that knowledge of the trade was a secondary consideration if the applicant had the required talents. For progress work, the applicant should first of all be judged for alertness, quickness, personality, and dependability. Without these qualities the applicant might do well in some other department, but he would be miscast on the progress staff.

Scientific management surely meant that they must plan to get the right man in the right job and the right type for the right job, and unless an employment manager had a considerable knowledge of the trade and a general experience of men, in his opinion he was not suited to hold that position. He knew very few employment managers in works in this country who were capable and qualified for the job. It was a serious state of affairs, if for instance you had a works manager who was not qualified and capable he didn't hold the job for very long, the same applied to a production engineer. So why should we tolerate scenic artists and such like holding the position of employment managers.

Mr. Denny had mentioned costs comparison. Mr. Melhuish said that he had especially kept off that. He was greatly interested in costs, as evidently also was Mr. Denny, and his experience in the various countries from a costs point of view, although he might not have mentioned it owing largely to the time it would take up, was that by far the finest costing systems and the cheapest costs per unit manufactured were to be found in the United States of America. India came second best in manufacturing costs owing to the very cheap labour in the East. In Calcutta they employed boys at five annas a month which was equal to 10d. They appeared to

be boys of about ten to eleven years of age—they couldn't say definitely because natives never knew how old they were—and they took those small native boys at five annas a month and trained them to operate Ward capstans, No. 3's, on surface grinders, and other machines of that description, and Mr. Melhuish said that he found that they were equally as good as any capstan operator he knew in Great Britain, probably better than a lot, and having regard to their ridiculous wages manufacturing costs were practically negligible. They turned out many gross of parts per week, and certainly many many gross per month for a cost of 10d. and it would therefore be appreciated that the cost of making those parts was practically nothing. Ironclad cubicles, switch boards for power houses, electric motors, and electric fans, etc., were made in Calcutta definitely cheaper than companies like the G.E.C. could manufacture them in Great Britain. That was after even giving the English and Continental companies the advantage of being on mass production as against batch quantities in Calcutta.

Mr. Melhuish thought that the third cheapest country in costs was Great Britain and the fourth South Africa, the last being Australia. Australia was last because their Unions had got so many lines of demarcation that workers could not work for making sure that lines of demarcation, say, between a sheet metal worker and a fitter were quite correct.

As regards inspection, Mr. Melhuish said that his remarks were based on a feeling which he had had at the back of his mind for many years. He said that naturally they could not immediately do away with inspection —that would be foolish if he suggested it, but he still claimed, as Mr. Denny had said, that their viewpoint should be that they could aim at doing away with inspection in the future by concentrating on the promotion of "foolproof" processes. He had been in works, probably the same as they had, and had many many times seen highly paid inspectors standing inspecting work coming off drilling jigs. He had seen inspectors in works in this country inspecting 100% where, under the conditions called for, 10% was sufficient. Therefore, he suggested that the aim should be "Foolproof everywhere" on machine work to commence with, so as to try and eliminate high inspection costs.

Mr. Butler said that he believed the lecturer had mentioned the question of content in reference to the worker, and he would like him to give them some idea of how this was to be achieved and what constituted content.

Mr. Melhuish, replying, said that he thought their friend had hit on the secret of works management. The most highly successful factories he had come into contact with were those with the most contented body of workers in them. He would cite an instance.

Earlier in the week he had visited a works where the managing director (an American by the way) of a large company, told him that he never experienced much trouble in his works simply because he believed in laying his cards on the table and only asking people to do what he could do himself, and by doing that, and giving them a square deal he very seldom found anyone who took advantage of it.

Mr. Melhuish thought that such an outlook was very wise and that many could profit by it. They had too many companies where the management looked down on the ordinary rank and file worker or the junior executive as so much dirt. That was where the works management acted foolishly. The successful manager, in his opinion, was one who realised that in a few years time the man down below might be the manager, and that whatever position they held they were human beings and were intelligent, clever people who should be treated just as he himself would wish to be treated. When that was done success was not far round the corner.

The type of executive referred to who treated workers with contempt was only asking for trouble, and was only asking for all the strikes and so forth which occurred from time to time. Mr. Melhuish said that as a matter of fact he had kept a record of the strikes in a number of works, and that he had found that firms which he knew were badly managed had the highest number. He knew a rubber works the works manager of which should, in his opinion, have been out of it long before for the simple reason that he could not control the workers because he did not understand them, and worse still despised them, and Mr. Melhuish said that he had found that over a period of five years this company had had more strikes, lock-outs, disputes, and general discontent than any other firm in Great Britain.

Thus control of labour simply meant that one had to apply psychological understanding in dealings with workers, and surely this meant decent civil treatment. There was no harm in saying to anyone, " Would you mind doing this ? " Speaking personally, he had never asked any foreman, assistant manager, progress man, or any other executive to do anything unless he had put it to them in that way, and such nicely put commands had always brought magnificent response.

In Australia, labour control was rather more difficult. Mr. Melhuish recalled an instance when at 10-0 o'clock one morning an Australian worker walked into an Australian works obviously in a condition brought about by many over the eight, and walking to the middle of the machine shop had lit a fire to warm his hands. He instantly paid the man up, and the men went on strike. That was quite common in Australia, and he found that he could only get contented workers there by constantly saying to himself, " You

are no longer in England " in an attempt to appreciate the Australian the better. He found that after a time, when he began to talk their " language " they thought more of him, and were more contented than they had been previously.

Believing that this viewpoint was necessary in every country he started off by treating the natives in India just as he would any man in Great Britain. The Europeans rose up in arms and said that black was black and white was white, but he still stuck to his argument. The result was that one time when there was a serious riot in Calcutta, and troops were forced to stand by, 300 of the boys who were employed at his works called for him first thing in the morning and escorted him to work and then took him home again at night. One night they were coming down the main street of Calcutta and the police who were ready to disperse any demonstration saw the crowd and were preparing to charge when a police officer saw his topee. The officer thereupon rode his horse through the crowd and asked him if he was in trouble. He replied that he was not and explained that the boys were escorting him home as they took him to and from home morning and night for safety. The officer was amazed at such protection afforded to a European, and the story went the round of the clubs in Calcutta. Mr. Melhuish said that the natives certainly did think a lot of him because he tried to treat them as he would treat any worker in Great Britain. He further illustrated this by telling of the instructions given to a steward on the Calcutta-Bombay train by one of the boys who came to the station to see him off, and the severe punishment promised should the steward fail to carry them out.

Mr. Gaunt said he would like to ask the lecturer whether he had any comments to make on the comparison of working hours in the countries he had mentioned, as he felt that the comfort and contentment of the worker was no doubt contributed to by the working hours, and he would like to have the lecturer's views.

Mr. Melhuish, replying, said that he entirely agreed and that, as one who had had a little experience in cotton mills in Lancashire, he was of the opinion that much of the discontent in the Lancashire textile industry was due to the ridiculous hours that managing directors still thought their employees ought to work. We had still got in Great Britain the old type of employer and the old type of managing director who was rather harsh and rather cruel in his outlook, and he existed chiefly in the textile industries in Lancashire. They were of the opinion that one should work sixty hours a week or something of that description. Mr. Melhuish said that he thought that we were fast changing and coming round to the American point of view. They had had a somewhat similar system in Australia for many years—they did not work Saturday mornings. The man-

agements and directors held the opinion that the time taken in travelling to and from work on a Saturday made Saturday a wasted working day. They worked five days of eight and a half hours, and they were considering reducing it to eight hours. Mr. Melhuish said that he thought it was essential to have a smaller working week, apart from curing unemployment and other things of that description. Personally, he was in favour of a five-day working week of eight hours a day. American and English friends of his, responsible for large engineering works in Russia, had told him in recent correspondence that within the next year or so Russia would probably introduce shorter working hours.

In India the average time was similar to ours—8-0 o'clock until 5-30—but they did considerable overtime. The hours in Australia were on the same basis, but as he had previously said, they had a five-day week of eight and a half working hours.

Mr. Melhuish said that there was one point he ought to mention and that was the fact that when we do work forty hours in five days we will have to remember that we have got to "pull our socks up." British workers are apt to be slow. After serving an apprenticeship in an up-to-date English machine tool works, he had at that time thought he knew it all, but after working on the bench with Italians, Swiss, Germans, Australians, and other nationalities, he found he was very slow. He was quite sure that in this country the average English worker was much behind the American and the Continental worker in the question of speed, and that if we adopted the five-day system we would have to do quite a lot of work in that time.

Mr. Cottell said that he would like the lecturer's views on the various systems of payment by result that he had experienced abroad, particularly the American systems such as Bedeaux, etc.

Mr. Melhuish said that the meeting would have gathered by now that he highly appreciated American methods, but if there was one method of the Americans he objected to it was their systems of payment by results. He claimed that the American systems were unsound in so far that the adoption of those systems involved a tremendous amount of clerical work. They were highly complicated, and the cost in clerical work was tremendous. He was also of the opinion that the systems in America like Bedeaux were not conducive to a happy and contented working force. He was not alone in holding that opinion. Many with whom he had come in contact thought that the Bedeaux system was in itself an acknowledgment of incompetent rate-fixing. Much discontent in the United States, and certainly in South Africa, had been caused because Bedeaux, Halsey, Rowan, and similar systems had been introduced.

On the other hand, he was no advocate of day work, and in no works where he was, did day work last very long. Workers took advantage of it, and initiative was stifled, because the best men did not get the best money. He thought they ought always to appreciate brains, intelligence, and quickness. He was definitely in favour of piece-work as operated in a number of factories in Great Britain, not as one found in clothing factories and boot and shoe factories where the workers were given a piece-work price and were paid only what they earned without a guaranteed basic rate. He thought that the fairest way was to pay a basic rate and give pure piece work over and above that rate. It did not involve the same excessive clerical costs, and in the majority of works promoted a happy and contented working force. Mr. Melhuish said that he probably should state that the many American systems of payments by results were practically identical. There was very little difference between any of those systems—they were all founded on the same basic principle.

Mr. Gaunt asked whether, in view of the lecturer's evident desire to be fair to his employees, the rate of pay for Indian boys quoted by him was inclusive of piece-work.

Mr. Melhuish, replying, said that it was rather a "ticklish" point, but he suggested that he was fair. When he left the works in Calcutta every boy in those works was earning 25% more than before his coming. Previously, they were not being paid on piece work, but a flat rate per month which, in his opinion, was inadequate and did not bring forth the best results, so department by department, commencing first in the foundry he instituted piece-work on the same basis we had in Great Britain. At first he was not quite sure how fast or how clever the native workers were, but after time studying them he had fixed piece-work rates which enabled them to earn over and above the standard rate of pay. Mr. Melhuish said that he thought piece-work was justified in all classes of work. He knew one company that manufactured electric lifts; they were on day work and they produced nine electric lifts per month. Piece-work was introduced, and in twelve months time that company was making 19 electric lifts per month.

Mr. Nadirshaw said that the lecturer, in speaking of executives in India, seemed only to refer to those who had gone out from England. He would be glad if the lecturer would let him know if he had at any time come in contact with executives of the New India. Was it not because the Indian executive had not yet had the full opportunity of proving himself, of applying his knowledge and thereby gaining practical experience, that in some cases and at first sight he perhaps appeared to fail? He had himself had the opportunity of visiting the Tata iron and steel works at Jamshedpur,

workshops run on modern progressive lines by a firm whose capital, administration, and executive were almost wholly Indian, and from what he could perceive, an extremely high standard of efficiency was maintained. The executives there had at first met with a number of set-backs, which was but natural since mechanised industry was in its initial growth in the country, but it was not long before these were overcome. As time progressed and the executives of the engineering industry in India gained in efficiency from their experience, it would be proved that they were not the worst executives in the world.

Mr. Nadirshaw could only think that the lecturer had during his short stay in India met with an exceptional series of experiences from which he drew his conclusions.

MR. MELHUISH, replying, said that probably he was a peculiar type of fellow, but when he was in India he tried to meet different types of people, including even Gandhi, because knowledge was born of this practice of studying and comparing different peoples and different types. Meeting Hindus and Mohammedans in Calcutta he had tried to find out where they differed from himself and other Europeans. Similarly, he had had a lot to do with the Indian executive. He introduced two into his own works to see if the European knowledge they had gained could be put to good effect. The average Indian executive was very clever and had good faculties for absorbing knowledge. They had acquired technical knowledge, and thoroughly understood it, whether it had been gained in the United States, in England, in the Colonies, or in India, but where they were lacking was in psychological understanding, driving power, and the ability to put the knowledge they had gained into practice. In his works there was one Indian executive who had studied really hard and was quite efficient in technical knowledge, but he did not seem to realise that he had gained that knowledge for a specific purpose, and that was to apply it to manufacturing engineering. However much technical knowledge a person had, unless he could apply it, it was valueless. When the Indian executive realised this he would make a big step forward.

Similarly in our own country we had young men who went to the right school, absorbed knowledge, and passed examinations, but they were not of much use in the works simply because they had not found the gift of employing their knowledge. The Indian executive was the worse for that lack of power of applying his technical knowledge to industry in general.

Keeping to the same plane of argument, he considered, after a long investigation, that the Russian practical engineer was the worst in the world, because the Russian was not mechanically minded, and up to now he was of the opinion, from experience in

the Indian executive was that he did not apply the tremendous powers he had got for absorbing knowledge, due to a large extent because he had not had the experience. Mr. Melhuish said that he was, however, looking at the matter more from a psychological basis, and in studying the Indian executive he had come to the conclusion that this failing to apply technical knowledge was not simply lack of opportunity but up to the present lack of evidence that he possesses the physical factors or faculties for that kind of work. That was not to say that the Indian executive would always be that way, but up to now, in his opinion, that was the trouble.

THE APPLICATION OF ELECTRIC FURNACES IN THE AUTOMOBILE INDUSTRY

Paper presented to the Institution, Coventry Section,
by A. G. Robiette, B.Sc.

THE automobile industry is one which embraces a considerable scope and includes not only the manufacture of engines and other components, but also accessories such as bumpers, screen wipers, etc., and other electrical equipment. Within this vast and thriving industry there are a number of interesting and intricate metallurgical processes calling for heat treatment and melting furnaces, and in this paper I will endeavour to review the subject of electric furnaces as applied to these processes. At the outset I would say that the automobile industry has taken advantage of what the electric furnace has to offer more than any other single trade in this and perhaps any other country. The conditions which obtain are all favourable to the use of electricity as a heating medium. In the first place the output of repetition parts is large, and this makes for continuous production—under which conditions the electric furnace is most advantageously operated. In less prosperous industries the drawback of first cost is a serious item which militates against the selection of an electric furnace even though it might be the best and most economical in the long run. Further factors which have promoted the use of electric furnaces in motor car factories are the convenience with which they can be placed in the direct line of production without reference to flues and pipelines, and the fact that very little heat or fumes are evolved means that they can be placed, without detriment, next to a piece of intricate machinery. Then, finally, the extremely fine control of temperature, heating time and, if necessary, furnace atmosphere, are all factors which make for uniformity of treatment irrespective in many cases of the human element. The consistency of product which it is possible to obtain is perhaps the most valuable asset of electric heating.

The processes which I will deal with include the melting and superheating of special cast iron heat treatment in the tool room, continuous hardening and normalising processes, carburizing, bright annealing, the application of controlled atmospheres, and the use of electric furnace brazing. These involve two distinct types of furnace, the arc furnace for melting and the resistance furnace for heat-treatment.

October 19, 1937.

Arc Furnaces for Melting.

The commercial application of arc furnaces to the melting of steels dates back more than thirty years but the use of this type of plant for melting and superheating cast iron is much more recent—most of the development taking place within the past ten to twelve years.

Many ingenious designs of arc furnace have been evolved in the past but most of these except two have more or less fallen by the wayside, so to speak, and we are left with the 3-phase direct arc furnace and the single-phase indirect arc furnace. These two types cover more than 90% of the arc furnaces in operation to-day.

The three-phase direct arc furnaces has three carbon electrodes arranged in a triangle overhanging a bowl shaped hearth. The arc strikes between the electrodes and the charge which must of course be conducting. The power liberated in the furnace is dependent on the length of the arc so that the carbon electrodes are arranged to move vertically towards and away from the charge. The external steel shell houses the refractory lining which may be acid or basic in character depending upon the metallurgical process to be carried out. For melting cast iron an acid lining of silica is mostly employed. The roof of the furnace is made removable as this is the least durable part of the lining. All these furnaces are made to tilt forward for pouring into a ladle and backwards for removing slag, if necessary, or repairing hearth refractories. On furnaces of 10 cwt., capacity and upwards automatic control of the electrodes, and therefore of the power, is now almost universally fitted.

The type of single-phase indirect arc furnace most generally employed has a horizontal drum shaped shell on the axis of which enter two graphite electrodes which strike an arc in the centre of the furnace. It is essential to rock the furnace through as wide an angle as possible to distribute the localised heat of the arc, whilst this motion also increases melting speed and ensures complete mixing of the molten metal. This type of furnace is limited in size by the single-phase load which it imposes and it is doubtful whether furnaces of more than half a ton in capacity will be built in this country for that reason. Its purpose is therefore restricted to making small melts of special composition and for applications where a large tonnage is not desirable such as in the manufacture of piston rings, tappets, liners, etc.

The next question which arises is what advantages are derived by electric melting and how does it compare on cost with other methods of melting ?

On direct melting costs alone it is about twice as costly as cupola melting or just over £1 more per ton. In many cases this difference in melting cost for the production of components required to stand

up to the service and rigid specifications called for in automobile work is entirely offset by the numerous advantages gained and savings in other directions. In the first place you can give the metal a controlled amount of superheat and this will give a denser iron and one having tensile properties between 35 and 65% better than an unsuperheated iron. It is possible to control the composition of the iron as regards C, Si, and if present Ni and Cr contents to within very fine limits. There is practically no loss or " pickup " of any material in the electric furnace with the result that whatever composition is aimed at is obtained. This ensures getting a uniform product of the quality desired without the need for exceptional skill or supervision. This, as you will realise, is of enormous value in the automobile industry. Even if a large proportion of the raw material is of a light character such as borings or turnings there is only an extremely small change in composition which enables this comparatively cheap scrap to be utilised economically thus reducing the cost of the product. If a sufficient supply of this scrap is available to dispense with the use of pig iron, then the cost of the product approaches that of the cupola.

Before touching on some of the applications of electric furnace iron I will briefly outline a further use to which the electric furnace has been put in the automobile foundry, namely, duplexing. For the mass production of cylinder blocks, heads, brake drums, and so on, it is more economical to melt in a cupola and run the product into an electric furnace where it is superheated, adjusted in composition, and poured if necessary on a continuous system. The cost of doing this adds something like 5s. to 6s. overall per ton lined, include the advantages obtained besides those already outlined, include the elimination of the need for pigging metal which has become too cold to pour, and also you have the fact that a reservoir of molten metal is always available of the right composition and temperature to cope with the needs of a foundry, which may fluctuate.

In Germany and America most manufacturers are duplexing for cylinder blocks. In this country two manufacturers, to my knowledge, are doing it. Of the products melted in the electric furnace we can instance large quantities of piston rings and liners, high tensile cast iron flywheels, parts in corrosion resisting cast iron, manifolds, camshafts, tappets, and one type of alloy cast iron crankshaft. These developments have come about in this country only within the past three years—their further expansion seems certain.

Tool Room Furnaces.

I will now pass on to heat treatment plant, starting in the tool room. The electric furnace is quite firmly established here and has

proved its value both for the treatment of carbon steels and also for high speed steels. Uniformity of temperature distribution in the furnace combined with automatic regulation of temperature and control of atmosphere have been factors which have played a large part in increasing the life of tools. The other aspect that must be considered is that if the electric furnace will eliminate the spoilage of a single complicated and costly tool, this will pay for the cost of hardening several hundred such tools.

As the requirements vary in a tool room, continuous methods of treatment are in most cases out of the question, and batch or box type furnaces are normally used. These are heated by nickel-chromium elements for temperatures up to 1,000°C., but for high speed steels elements of a silicon carbide composition are required. It is, however, the introduction of a controlled atmosphere which has had such a profound effect upon the heat treatment of tools. In the first place the fact that a box type furnace has mostly to be used, means that every time the door is opened the effect of this atmosphere is lost. This drawback is overcome in the " certain curtain " furnace by providing for an effective screen or curtain of a combusted gas and air mixture across the vestibule of the furnace to prevent the entry of atmospheric air. Moreover, a suitably controlled atmosphere can be inserted independently into the furnace during the whole heating period. This gas mixture is predetermined and controlled so that the gas is non-decarbonising and non-scaling to the particular steel being treated. As electric heating is independent of any external condition, and as it is quite simple to make an electric furnace gastight, no muffle is required and the atmosphere is readily controlled. In this way it is possible to eliminate scaling to such an extent that final lapping of tools can in most cases be dispensed with. This is the case even with such delicate tools as H.S. steel threading taps which are now ground prior to hardening. A further advantage for high speed steel is that it is possible to keep the tool in the furnace longer to ensure efficient soaking without running the risk of embrittling the material by excessive grain growth and penetration of oxide. It thus gives the operation a very much greater margin of safety.

As regards the cost of hardening this will vary widely with the output and nature of the work treated, but the following figures can be taken as a rough guide of what may be considered average practice. For carbon steel tools about 4 to 5 lb. of work can be hardened for 1d. including the cost of electricity and gas, whilst it costs from .8d. to 1d. to harden 1 lb. of H.S. steel, this cost including electricity, gas, and charges for the replacement of elements.

Before leaving the toolroom a word must be said about tempering. Oil and salt baths because of uncleanly conditions of working

are rapidly being replaced by forced air circulation furnaces. To overcome the disadvantage of slow and ununiform heating by radiation at low temperatures—below 600°C.—a fan is employed in this type of furnace to accelerate heat treansfer by convection. This fan rapidly circulates the air over the heating elements and subsequently through the charge. A thermo-couple is placed in the air stream as it leaves the heating elements, and another as it leaves the charge. When these two thermo-couples show the same reading, preferably on a recorder chart, you are certain that the whole charge is up to temperature throughout its mass, thus eliminating human judgment. The operating cost of this type of furnace compares favourably with fuel-fired equipment, and it is being very widely used for tempering and other operations requiring temperatures below 700°C., including the heat treatment of aluminium alloys.

Carburising.

The question of electric versus other forms of heating for carburising has been one which has several times been discussed in technical journals, and I only propose to lay before you a few facts. The largest gear manufacturers in this country use electric carburising exclusively, whilst many motor car manufacturers and makers of components employ electric furnaces to a very large extent. Most of the controversy has arisen over the cost of treatment. In certain instances a fuel-fired furnace may show a somewhat lower cost than an electric furnace, but when you bear in mind that parts such as gears may be worth £250 to £500 per ton is the matter of, say, 5s. per ton in the cost of treatment of such vital importance if real advantages are to be gained ?

What then does the electric carburising furnace offer ? A properly designed furnace can guarantee uniformity of temperature which ensures uniform case depth throughout the charge. Automatic temperature control is fitted universally whilst the furnace can be controlled entirely during night operation (when current can usually be obtained at a low rate) without the need of any supervision. Then the cleanliness of working conditions, the longer life of boxes, and probable reduction in labour costs are all factors to be borne in mind.

Naturally, the cost of carburising will vary widely with local requirements and conditions, but the following will serve as an example. For carburising gears (case depth of 40 thou.) at a temperature of 910°C. for ten hours a figure of 390 units per ton of gross load (work and boxes and compound) can be obtained. This corresponds to 1,170 units per ton of work at a 3/1 ratio.

If conditions are such that there is a big output of repetition work calling for the same size boxes and the same time cycle, then

continuous contraflow recuperative pusher type furnaces can be used with a saving of up to about 30% in running costs.

Nitriding.

This process has had only a limited application in the automobile industry, but it is quite widely employed in aircraft work. Electric furnaces owing to the certainty of giving uniformity of temperature are, practically without exception, the only plant used for this process. Batch or box type furnaces were the first to be employed, but these necessitate inserting a gastight box into a furnace and either leaving it to cool down with the furnace, or having flexible gas pipes to enable the box to be withdrawn while hot, thus leaving the furnace free to receive a second charge. This is a very inconvenient method of processing, and one which can only be tolerated for small furnaces. For large scale production the duplex semi-continuous furnace is that which is being adopted, and I shall explain it by means of a few slides. I should also point out that as this process involves extremely long soaking periods, and as the thermal loss from a heavily insulated electric furnace is extremely low, it is in most cases more economical to operate than fuel fired furnaces.

Production Heat Treatment.

Under this heading I will deal with the hardening, normalising, and annealing of parts such as gears, crankshafts, axles, and other heat-treated components which go to make up a modern car. For small varied production then a batch type furnace, manually or mechanically charged, is to be recommended, but where a case can be made out for a continuous furnace it should be employed every time. A continuous or mechanised hearth furnace in which the material is charged in single pieces or in small batches and transported through the same temperature conditions at a controllable rate guarantees that each single piece has received the same uniform treatment—eliminating the human element almost entirely.

Remarkable strides have been made in mechanising furnaces in recent years particularly as regards automatic charging and discharging devices. It will be impossible for me to describe in detail the multitudinous types of furnace within the time available to-night, so I propose to illustrate some and point out their main features by means of some representative slides.

Protective Atmospheres.

Nowadays very few people seem to be interested in the conventional type of box furnace into which they were content to put in a piece of metal and bring it out with a varying amount of oxide or scale on it. They wish to eliminate scaling either more or less completely, and so avoid having to clean the material by pickling,

sandblasting, barrelling, and other processes. It is also important to obviate the tendency of certain steels to produce a soft skin which is caused by loss of carbon from the surface, namely, by decarburisation. Modern requirements therefore call for cold worked parts such as stampings, pressings, tubes, etc., with their bright clean surface, to be annealed, normalised, or otherwise heat treated and still retain that surface finish unimpaired. Machined parts such as gears, tools, dies, roller bearings, and so on, are also required to be hardened and often tempered without the production of any scale and without any decarburisation. This enables the manufacturer to finish machine all his parts before heat treatment, and to dispense in many cases with final grinding or lapping, to say nothing of sandblasting, barrelling, and other irksome cleaning operations.

The next question arises as to how it is possible to prevent this oxidation as well as other surface defects. In many cases it merely means making the external shell of the furnace gas-tight and admitting a specially produced gas without the need of any refractory or metallic muffle. In other cases, such as the annealing of strip and wire, the fact that the heating does not entail severe flame conditions and sulphur-bearing gases renders it possible to use containers made of thin welded heat-resisting alloy with an expectation of a long life.

The most difficult problem however was the production of relatively pure artificial atmospheres or gases, without the need for expensive plant and skilled operatives for working it.

Oxidation, although a general term, takes place under widely different conditions. The problem is not simply one of eliminating oxygen or air from the furnace as was once thought. In many cases water vapour and carbon dioxide can produce just as much oxidation of certain metals and there are gas mixtures which are oxidising to some metals and reducing to others. I do not propose to go into the chemistry of these gas-metal reactions now, but I would be pleased to do so in the discussion if anyone is interested. Also, sulphur and oil fumes have to be rigidly eliminated as the oil will deposit soot on the work and the inside of the furnace chamber, whilst sulphur will attack most metals as well as the elements and other furnace parts. However, it will be sufficient to say that it is now possible to bright anneal or otherwise heat treat almost every existing metal or alloy with gas mixtures whixh are relatively inexpensive to generate.

These gases are mainly produced by the partial combustion of ammonia or town's gas followed by subsequent drying and/or purification. Ammonia is not economical to use directly and it has to be recuperated by recirculation. This has been very successfully

done but the plant involved is rather costly. Burnt ammonia is essential for brass, stainless steel and other alloys difficult otherwise to bright anneal. Burnt town's gas is used very largely for steel pressings and hardened parts. In the case of both gases the plant is automatic in operation. Not only can bright hardening or normalising be realised but parts already oxidised can be descaled by passage through the furnace. What happens is that the scale is reduced chemically to the metal by the action of the gas.

To prevent carbon loss or decarburization during the hardening of steel it is essential to use an atmosphere in which the decarburizing gases such as carbon dioxide and hydrogen and also water vapour are balanced by carburizing gases such as carbon monoxide and hydrocarbons. These gas mixtures will be different for varying carbon contents and also for different temperatures, but it is possible to produce mixtures of this type from burnt coal gas or from charcoal for almost every steel on the market.

The extent to which these processes are being used to-day may be gathered from the fact that about 30% or more of electric furnaces now being made are arranged to work with a controlled atmosphere similar to those which I have described, and the cost of protective gas per ton of material treated in most cases is negligible compared with the resulting savings.

Electric Furnace Brazing.

The application of protective atmospheres has made possible a process which has aroused considerable interest in the automobile industry, namely, electric furnace brazing. It is a process of assembling or building up relatively complicated parts from two or more components—in steel or other alloys. Copper and brass are the most usual brazing alloys employed and wire, strip or paste of these materials is located between or near to the joint to be made, The component parts are generally made a press fit or they may be located by spot welding or by jigs. The whole assembly is passed through a furnace on a belt conveyor or on trays at a temperature just above the melting point of the copper or brass. The brazing material then flows by surface tension into the gap between the parts. This fit, for the highest strength, should be between one and two thou. but up to four thou. can be tolerated. The fact that a controlled atmosphere is used means that no flux at all is necessary for steel parts and after brazing the parts are perfectly clean and bright. In most cases the location of the copper wire or strip is relatively unimportant as long as it is near the joint, since when it melts it will be attracted into the capillary space. Another advantage is that it is possible to use just sufficient copper to fill the gap with no large excess which otherwise would have to be cleaned off. The

amount of brazing material used is, therefore, a minimum.

As regards the strength of the joints some of you will be surprised to hear that a braze properly made in this way is stronger than if the parts were made solid. This is due to the fact that if the clearance is of the order of one thou, then the material at the joint is not copper but a copper-iron alloy which is slightly stronger than steel. The steel parts after brazing have a normalised structure, but in many cases heat treatment can be effected afterwards if desired.

It is common to make several joints at a time and the big advantage of the process lies in the fact that complicated and expensive assemblies can be fabricated from comparatively cheap pressings or stampings and in many cases much machining is avoided. It will be realised that in many cases slight revision in the design of parts may be required before this process can be conveniently adopted. Once, however, the design and method of assembly have been settled the process becomes a continuous one, requiring very little skill or supervision. All the operators have to do is to lay the parts after assembly on to a belt or tray. This process is being rapidly taken up by the automobile and allied industries, and I can explain its manifold applications better by reference to some samples and illustrations.

Conclusion.

This paper has been, I know, a very sketchy and incomplete review of a very wide subject. Several omissions have been made, and I have only attempted to emphasise some of the more important applications of the electric furnace in this industry. I trust, however, that any member who would like me to go into more detail upon any particular aspect will say so in the discussion, and I will endeavour to do so in my reply.

Discussion.

MR. SINCLAIR (Section President): I feel sure you will agree you have listened to a most interesting and enjoyable discourse. I have had to face a problem associated with the case-hardening of parts and have turned my attention to electric furnaces. It was brought to my attention that Americans are using a process in which they claim a very rapid carburising of fairly great depth, using an electric furnace, which appeared to me in comparison with those shown on Mr. Robiette's slides something after his tempering type, sunk into the floor. The carburising medium was oil, dripped into a hardening chamber at a predetermined rate. The furnace was controllable, and actually had a fan at the top as a means of circulating the carburising medium. It was capable of application to nitriding. Has any work been done over here on carburising on the oil drip method?

MR. ROBIETTE: The process referred to is what is called the "carbonal process" developed in America, and it uses I think a nitrogenous type of oil, which gives a case very similar to a cyanided case. That type of case has not been favoured by motor car manufacturers in this country, because it tends to be brittle. The American car manufacturers don't hold with box carburising to the same extent as we do. By this method the oil is dripped on to the work and is spread throughout the charge by means of a fan, but there is apparently no great demand for it in this country. Most manufacturers who want that type of case have turned to cyanide.

MR. GRIFFIN: I feel that this question of furnace atmosphere is by no means settled, and we are almost as much in the dark now as we were two or three years ago. I refer to the subsequent hardening processes. I am afraid electric furnaces occasionally trip up on plain case hardening parts. Under these circumstances I feel that to get the absolute maximum results we have got to go back to gas furnaces for hardening. This business of control, although easier on problems like scaling and bright annealing, becomes more critical when you turn to the question of soft spots. It does nothing to eliminate soft spots.

I can substantiate Mr. Robiette's statement about high speed electrical furnaces, because during the last few months I have thought mine were slower of heating. I have found that an operator when first put on to working a high speed furnace almost always makes the mistake of under soaking. I am able to prove—in fact it was demonstrated as short a time ago as this afternoon—that Mr. Robiette's statement about their being safer to operate is true.

But you are up against this, if you want only the tip of a tool hardened, that is where the electrical furnace slips up. That is the only objection I have.

MR. ROBIETTE : Dealing with the second point first—the speaker found his own solution to the third problem he spoke of—hardening tips of tools. The ordinary box type of furnace is of no value whatsoever. You must go to salt baths, which prevent decarburisation and give local hardness. These are better than gas furnaces. As regards the hardening of plain carbon steels, the question of soft spots is not entirely one of decarburisation. It is often a matter for the steel maker. If decarburisation takes place it takes place more or less uniformly over a large area. Soft spots cannot be cured to any extent at all by furnace atmosphere. As regards reheating of plain carbon carburised work you can eliminate scale and get no decarburisation. We have developed within the past nine months atmospheres which are perfectly non-decarburising to plain carbon steels. The atmospheres which were previously used, generated from coal-gas, were not entirely suitable for plain carbon steels. Possibly, if you had a definitely oxidising atmosphere the soft spots would not appear to such a great extent.

MR. GRIFFIN : With regard to soft spots, we are about to send back a batch of steel for abnormality, but there again we are working on certain conditions of a slightly oxidising atmosphere which gives better results on certain parts. Our furnaces are equipped not with charcoal but with town gas, and I had thought of charging one of these combustion chambers with charcoal and try and change it.

MR. ROBIETTE : I don't think it would house sufficient charcoal.

MR. SINCLAIR : I am sorry I don't agree altogether with the lecturer in the question of soft spots. The matter of soft spots is one I have paid a great deal of attention to in connection with boring bar holders which have to be dead hard all over. We have tried them carburised in mild steel, and we have tried them in an electric furnace and in natural gas furnaces, and we still have soft spots. I find that you might have a soft spot in one place, and when you reheat it that soft spot disappears from the first place and appears in another. We cured this by using a pressure gas burner. By doing that we got rid of at least 90% of soft spots. Abnormality in steel is a very rare thing, isn't it ? I have never been able to find any natural draft furnace which would cure that in mild steel, and an electric furnace is not any better at doing this, is it, than a natural gas furnace. The trouble of soft spots, I find, usually happens over 850°. So I say heat it in an atmosphere which is moving and turbulent all the time. The next point concerns this curtain of gases. How do you manage to maintain it ? My experi-

ence is that it is very nice when it is new, but after being used for some months the curtain disintegrates and fails in certain places. You don't get a perfect curtain. As regards tempering furnaces, I think the air circulating tempering furnace is the most perfect thing the electric furnace people have done. As regards high speed steel, I should like the lecturer's observations on the carbon neutral system.

Mr. Robiette : I think the speaker's observations have proved that soft spots are not due to decarburisation. Therefore, you cannot do anything as regards making the atmosphere more carburizing to prevent the soft spots occurring, because they are not due to decarburisation. If you already have a soft spot in one place and when you reheat it that soft spot appears in another place, then I don't see how it can be due to anything connected with loss of carbon from the surface, because once that carbon is lost you cannot put it back. I think it is entirely due to a condition in the steel.

Mr. Sinclair : How is it that if you put it into a pressure fed gas furnace the soft spot goes ?

Mr. Robiette : I am afraid it is one of those problems to which no one has yet found a satisfactory answer. I think it is best to admit that. As regards the " carbon-neutral " salt bath, it has practically all the advantages that an ordinary box type furnace has, except that you cannot control your temperature so accurately. Some operators, of course, won't work a salt bath because of the fumes.

Mr. Sinclair : Put a cowl over it and draw the fumes off.

Mr. Robiette : The operator still has to bend over the bath, and thus gets a certain amount of fumes.

Mr. Sinclair : Put the bath up high where the operator doesn't have to bend.

Mr. Robiette : There are not many disadvantages to the salt bath, except those I have just mentioned, although they can be partially overcome, I agree.

Mr. Boyes : I was interested in your furnaces and would like to ask if, when the pressings have been brought into the shop, any treatment is given to them as regards cleaning the surface or scraping before they are put together and the wire put round ready for brazing. Also, is pure copper necessary, or would an alternative, rich in copper content, serve just as well ? I think Mr. Robiette mentioned that a space of four thous. was sufficient for the copper to flow into. Does that mean a uniformity of space all round is essential ? Would there be any loss should part of the space be more than four thous., say, 10 thous. ?

Mr. Robiette : As regards cleaning the parts, usually the pressings have a small amount of grease on them and nobody bothers

to clean this off. If the pressings were saturated with oil, it would be advisable to remove the greater part of this oil, from the point of view of damage to the furnace parts. As regards the fit of the parts, if you had a clearance of four thous. generally round the circumference and a small gap larger than four thous. you would not get any copper at that point. The strength of the part would probably be sufficient—in fact there is no doubt that it would—but most people like to see the parts joined so that there is no gap whatsoever. No difficulty has been experienced in getting pressings, however, where this variation does occur. The ideal treatment is to keep the parts in the furnace just long enough for the copper to flow freely and evenly into the joint. If you keep it too long in the heating chamber the copper will run out at the point where the variation in space occurs, but it will remain in the rest of the capillary space. It is not essential to use copper, but it seems to make the best joint, and a joint with copper is made much easier than with anything containing zinc, because when a zinc oxide is formed the metal does not flow so freely. Parts can be readily brazed with 30% zinc, although it is easier to produce a good join with copper than with brass.

CORNISH SECTION, INAUGURAL MEETING

The Inaugural Meeting of the Cornish Section was held on Friday, 8 April, 1938 in the Lecture Theatre, School of Mines, Cambourne.

Among the 93 members and visitors present were : The Right Hon. Lord Sempill, *Immediate-Past-President*, Messrs. J. H. Bingham, *Chairman of Council*, W. F. Dormer, G. H. Gales, J. G. Young and R. Youngash, *Members of Council*, R. Hazleton, *General Secretary*, and W. Marsden, *Assistant General Secretary*, P. M. Holman, *Messrs. Holman Bros., Ltd.*, C. R. Perks, *Members of Western Section Committee*, and Mr. Rickard, *Messrs. Climax Rock Drill and Engineering Co., Ltd.*

Many letters for apology for absence were read from members of Council and Section Committees, all of whom conveyed their best wishes for the success of the Cornish Section.

It was unanimously agreed that a Cornish Section be formed and that it be centred at Cambourne. The following officers were elected : Mr. J. G. Young, *Section President*, Messrs. John Arthur, W. J. Bennett, J. Glasson, P. Tromans, G. Clifton, Capt. Spenser, and J. F. Holman, *Members of the Committee*. Mr. John Arther was appointed *Honorary Secretary* and M. T. A. Holman was nominated as *President-Elect for Session* 1938-1939.

A hearty welcome to the new Section was conveyed in speeches by Lord Sempill, all the members of Council present, Mr. R. Hazleton, Mr. J. G. Young, Mr. P. M. Holman, and many others.

Following the inaugural proceedings Mr. W. Puckey, M.I.P.E. gave a lecture on " Personal Problems of Management " which was followed by a keen discussion.

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